POWER

Vol. 37 NEW YORK, APRIL 22, 1913 No. 16

Look to Your Boiler Room

THE more complete and exact an engineer's knowledge is of the science of steam engineering the more successful he should be. The best surgeon is not always he who has the handsomest set of instruments but he who can use those which he has in the most skillful way. Likewise, the best engineer is not necessarily he who has the most pleasing looking plant but he who gets the best obtainable results with the apparatus he has charge of. And, other things being equal, the man who is best versed in the philosophy of the art will secure the best results, because he can test to find out whether the results he is getting are good, bad or indifferent. Thus, from his observations and by his knowledge he can diagnose the trouble when any is present and take the necessary steps to overcome it.

The boiler room has long been neglected. It is still left too much to take care of itself.

Engines fitted with suitable governors and given a rational quantity of lubrication will do their duty without any particular attention, and with economy which at least is uniform in degree. No need for personal manipulation to meet every slight variation of load or requirement—the engine responds automatically.

In the boiler room, however, things are different. Here, the personal element is a big factor. Intelligence and skill count for much. Yet, not only is the fireman often hired solely on his physical qualifications, but after he is hired, his work is usually but poorly supervised and his training is seldom thought of at all. As long as he holds the steam pressure where it belongs, he is not asked to do more.

Now, this is all wrong. The fuel is usually the biggest item in the cost of power generation. A dollar will buy so much coal. So much coal contains so much heat. After paying your dollars, why not use as much of the heat that you have bought as you possibly can? To burn coal so that the maximum of its heat will go into the water and form steam is a fine art.

Every engineer should know the limitations of his boiler equipment so well that he can get the best results under all conditions.

On page 582 of this issue we print the first of a series of articles dealing with boiler-room economy. These articles will tell "the whole story" from start to finish and will follow each other in logical order so that when the last one has been read—and digested—the reader ought to know all the fundamental facts about the economical combustion of fuel.

In this series the writer will take nothing for granted—everything, no matter how simple it may seem to some, will be fully explained. If you don't fully understand every statement made, don't let the matter slide. Write to us telling us just what it is you don't understand. Your letter will be treated with strict confidence and you will receive a prompt reply with the additional information needed.

Power Plant of Jacksonville Traction Co.

SYNOPSIS—A 2400-kw. reciprocating-engine power plant, generating electrical energy for street-car service. The engines operate condensing and are supplied with steam superheated 75 deg. F. Three 600-hp. water-tube boilers, designed to generate steam at 200 lb. pressure, are used.

Jacksonville, Fla., has a population of, approximately, 59,000 inhabitants and is well supplied with street-car service, the power to operate which is generated at the new power house of the Jacksonville Traction Co. This plant is on Riverside Ave., on the water front of the St. John's River. It is on a four-acre lot, graded to bring it above the water level.

Owing to the nature of the soil, it was necessary to drive about 1300 piles under the station foundation. The site, improved by filling in, is approximately 48,000 sq.ft. in area and reaches from the street to the water front. The building is a one-story structure of brick and steel with concrete footings, as shown in Fig. 1, and has a lawn in front.

Entrance to the engine room is through the engineer's office, at the right front corner of the building. There are two cross-compound engines directly connected to direct-current generators of 1200-kw. capacity each. The cylinders are 27x60x48 in. and a speed of 100 r.p.m. is maintained with 150 lb. steam pressure. These engines have covered tail rods, as shown in Fig. 2. Views of the valve gear of the high- and low-pressure cylinders of these engines are shown in Figs. 3 and 4. Three eccentrics are used, one to operate the exhaust valves, one for the steam valves and a third to operate the valve-cutoff gear, thus relieving the governor of undue friction.

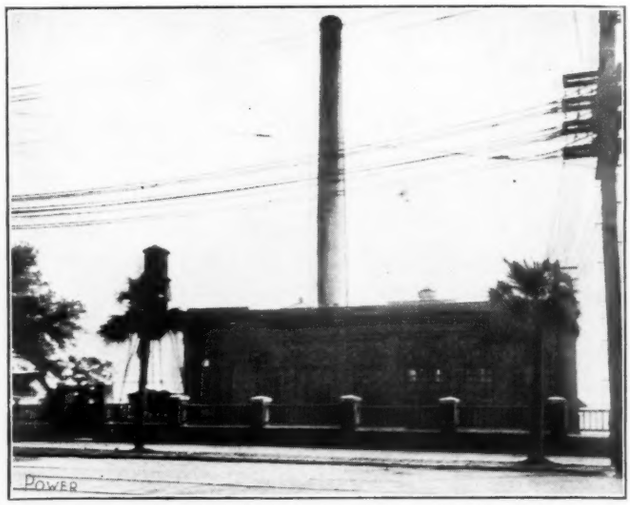

FIG. 1. POWER PLANT OF THE JACKSONVILLE TRACTION CO.

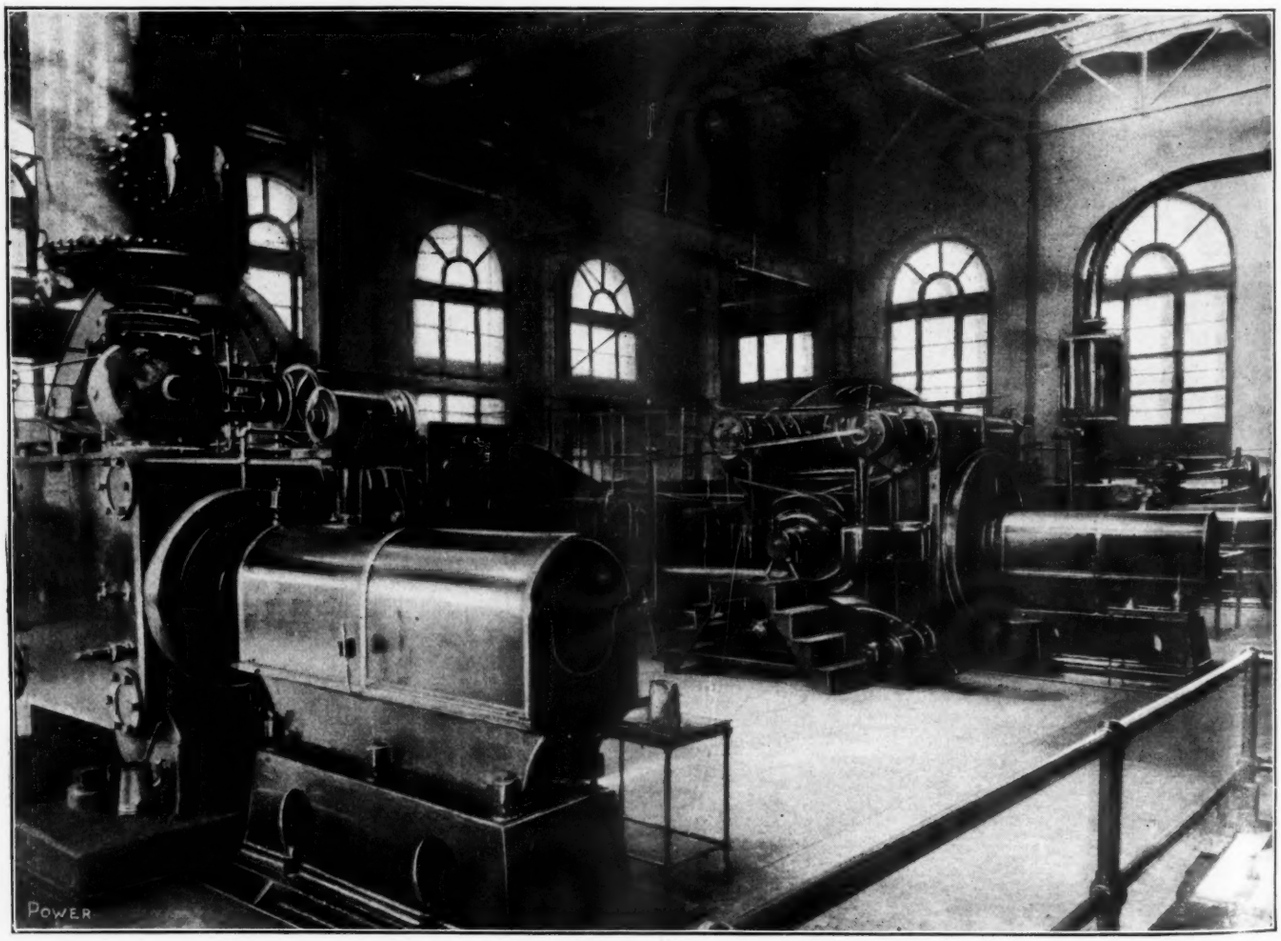

FIG. 2. VIEW OF THE ENGINE ROOM, SHOWING THE TWO RECIPROCATING UNITS

Steam is supplied through 6-in. steam pipes connected to a 12-in. steam header in the boiler room at the back of the boilers. Steam pipes drop down from the boiler outlets to this header, which is placed about 5 ft. above the boiler-room floor. A small 50-kw. unit, consisting of a three-phase, 60-cycle, alternating-current generator and exciter, is driven by a 600-volt direct-current motor, and used for station lighting.

Both main engines are lubricated in a manner not found in most plants. Instead of piping a lubricator to the steam pipe next to the engine, one is attached to each branch pipe leading to the engine, just above the main header. The oil-discharge pipes of the lubricator extend nearly across the steam pipe and are perforated on the top sides. This way of feeding the oil insures its being thoroughly mixed with the steam before it reaches the engine cylinders. The lubricating oil is returned to a filter of 150 gal. capacity per hour.

The main engines exhaust into two barometric condensers, which are between the boiler settings and the wall separating the boiler and engine rooms. Water is supplied to the condensers by two 12-in. centrifugal circulating pumps of 3000 gal. per min. capacity, which are directly connected to 8x11-in. horizontal engines. The water comes to the pumps through a 7½x5-ft. intake 725 ft. long, extending from the power house to the river front, 12¼ ft. below the low-water level. The intake screen walls, constructed of reinforced concrete, extend 17 ft. below the low-water level. A double tunnel of reinforced concrete runs through the building and extends 12 ft. back of it, 15 ft. below the low-water level.

Pumps

All pumps are in the basement under the engine room. The two rotating, horizontal, dry-air, vacuum pumps are 10 and 18 by 18 in. in size. The two 14 and 8½ by 15-in., duplex, center-packed, plunger, boiler-feed pumps,

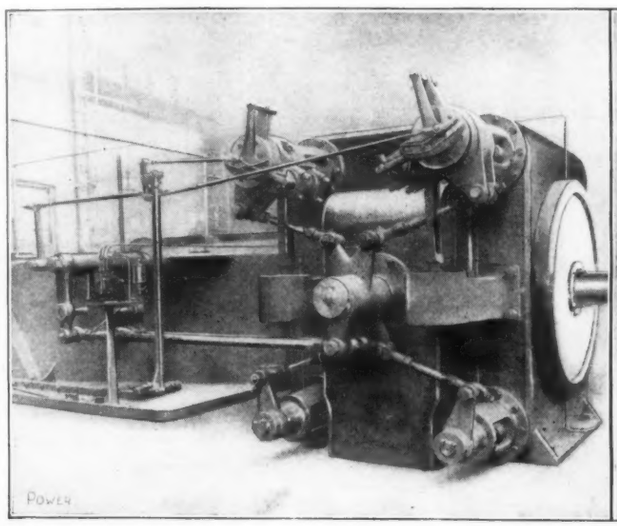

Fig. 3. Low-Pressure Valve-Gear

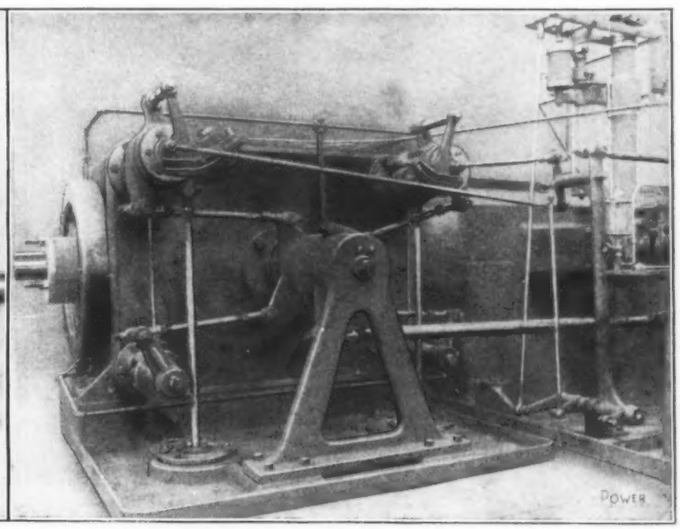

Fig. 4. High-Pressure Valve-Gear

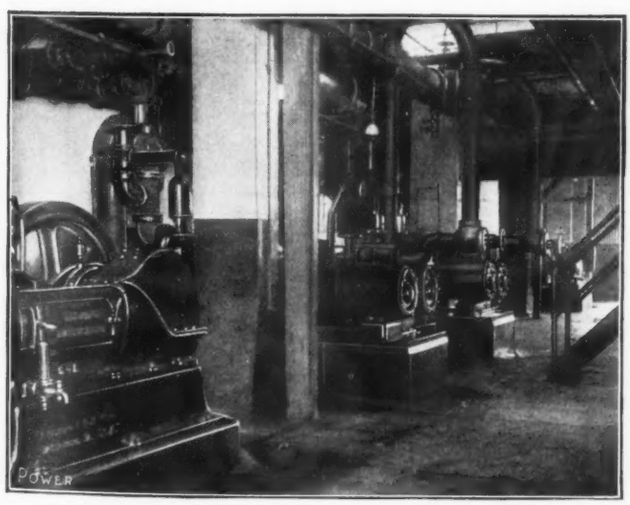

Fig. 5. A Portion of the Pump Room

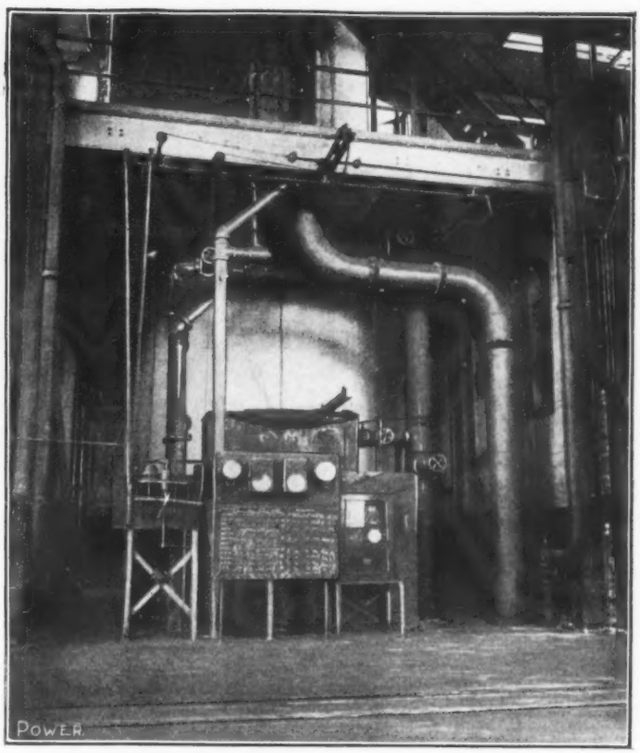

Fig. 6. Heater, Receiving Tank and Water-Recording Meter

with a capacity of 250 gal. per min. each, are about midway of the pump room, as shown in Fig. 5. There is also one 7½ and 8½ by 10-in., duplex, low-service pump, with a capacity of 250 gal. per min., and one 2-in. centrifugal, low-service pump, of 100 gal. per min. capacity, directly connected to a 7½-hp., 600-volt motor. An 18

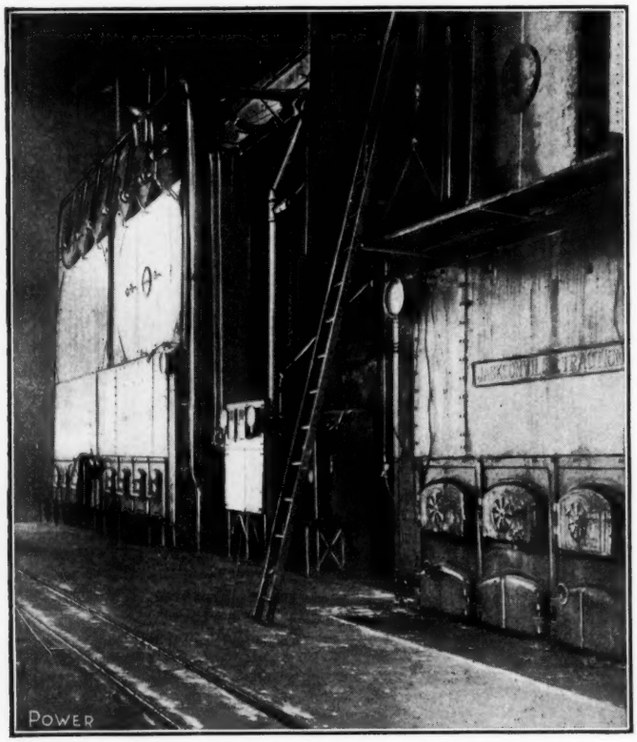

FIG. 7. PARTIAL VIEW OF THE BOILER ROOM

FIG. 8. UNLOADING COAL FROM A SCHOONER

and 10 by 12-in. underwriter's fire pump, with a capacity of 1000 gal. per min., is at one end of the pump room. This room also contains a 9½ and 13 by 10-in. air compressor, with a capacity of 92 cu.ft. of free air per min.

EQUIPMENT OF THE JACKSONVILLE TRACTION CO.'S POWER PLANT

No.	Equipment	Type	Purpose	Kw.	Volts	Hp.	R.p.m.	Size	Steam Pres. lb.	Maker
2	Engines	Corliss	Main units	1200	...	..	100	27x60x48″	150	Nordberg Mfg. Co.
2	Generators	Direct current	Main units	1200	600	..	100	...	...	General Electric Co.
2	Condensers	Barometric	Engines	..	...	..	...	57″	...	Mesta Machine Co.
3	Boilers	Water tube	Steam gen.	..	...	600	...	....	150	Edge Moor Iron Works
2	Pumps	Duplex	Boiler feed	..	...	..	...	14x8½x15″	150	Henry R. Worthington
1	Pump	Duplex	Low service	..	...	..	...	7½x8½x10″	150	
1	Pump	Centrifugal	Low service	..	...	..	...	2″	...	
1	Motor	Direct current	Centrifugal pump	..	600	7½	...	....	....	General Electric Co.
1	Heater	Open	Feed water	..	...	3000	...	....	...	Warren Webster & Co.
2	Pumps	Centrifugal	Circulating	..	...	..	...	12″	...	Alberger Pump & Condenser Co.
2	Engines	Horizontal	Cir. pumps	..	...	..	...	8x11″	...	
2	Pumps	Horizontal rotative	Dry vacuum	..	...	..	...	10x18x18″	...	
1	Pump	Underwriters	Fire	..	...	..	...	18x10x12	...	Henry R. Worthington
1	Water softener	Kennicott	Feed water	..	...	..	...	10,000 gal. per hr.	...	Kennicott Water Softener Co.
1	Recorder	Lea	Feed water	..	...	..	...	125,000 gal. per hr.	...	Yarnall-Waring Co.
1	Stack	Concrete	Smoke	..	...	..	...	9′x200′	...	General Concrete Construction Co.
2	Pumps	Duplex	Oil	..	...	..	...	3½x2½x4″	...	Henry R. Worthington
1	Compressor	Westinghouse	Air	..	...	..	...	9½x13x10″	...	Westinghouse Air Brake Co.
1	Crane	Motor travel	Engine room	..	...	..	...	30 ton	...	Niles-Bement-Pond Co.
1	Scale	Track scale	Coal	..	...	..	...	36′	...	Fairbanks Co.
1	Filter	Fleur-de-lis	Oil	..	...	..	...	150 gal.	...	Boston Steam Specialty Co.

Two 3½ and 2¼ by 4-in. duplex oil pumps handle the oil used in the engine-lubricating system.

BOILER ROOM

Three 600-hp., water-tube, hand-fired boilers, each equipped with a superheater, supply steam at 150 lb. and 75 deg. superheat. The tops of the boiler settings are flat, with concrete filling, and a concrete platform is built between the single boiler setting and the battery of two boilers, as shown in Fig. 6. A 9x200-ft. reinforced-concrete chimney stands between the two sets of boilers. The 3000-hp. open heater is on a platform level with the top of the boilers; the exhaust pipe from the auxiliaries enters it at the end. The return and cool makeup-water tank is on the boiler-room floor below the heater, and in front of it are the damper regulator and water-recording meter, the latter having a capacity of 125,000 lb. per hr. This arrangement centralizes all of the boiler-room apparatus at one point, convenient for observation and attention. Fig. 7 is a part view of the boiler room.

In the yard is a 30,000-gal. overhead fire tank, with a head of 90 ft. and a 30,000-gal. overhead water-storage tank, with a head of 60 ft. Both tanks are supported by the same structural work, as shown in Fig. 1.

All feed water is treated in a water-softening plant, having a capacity of 10,000 gal. per hr.

Coal is shipped to the plant by water and unloaded into a car by a steam-driven locomotive crane, Fig. 8, having a capacity of 17 tons per hr. at a 10-ft. radius. When the coal car is loaded the locomotive crane draws it the length of the 380-ft. wharf to the 4000-ton coal-storage space, outside the boiler house, where it is unloaded from the car by the crane and clam-shell bucket to the storage pile, or is unloaded at the boiler house into a small coal hopper. Under the latter the boiler-room firing car is run, loaded and, after being weighed on a track scale, pushed to any boiler.

The average coal consumption is 2.24 lb. per kw.-hr. for a 24-hr. run. A better showing than this would be made were it not for the inefficient load between 12 midnight and the time of the heavy morning load. The average load for the 24 hr. is 2300 kw. A reproduction of the log sheet used at the plant is given in Fig. 9.

Nine years ago a 250-kw. unit was sufficient to handle the street-car service for the city. Then a 300-kw. unit was added, and, five years ago, an 800-kw. unit was installed in the old plant. The present plant, it is estimated, will supply the city with street-car service for 100,000 inhabitants. The ultimate capacity of the plant will supply the needs of 400,000 population.

Actual work of excavation for this plant began Apr. 3, 1911, and on Nov. 1, of the same year, one engine was started noncondensing. On Feb. 10, 1912, the station was ready to deliver power with the No. 1 engine running condensing, and, on the 26 of the same month, the plant was turned over to the operating company, complete.

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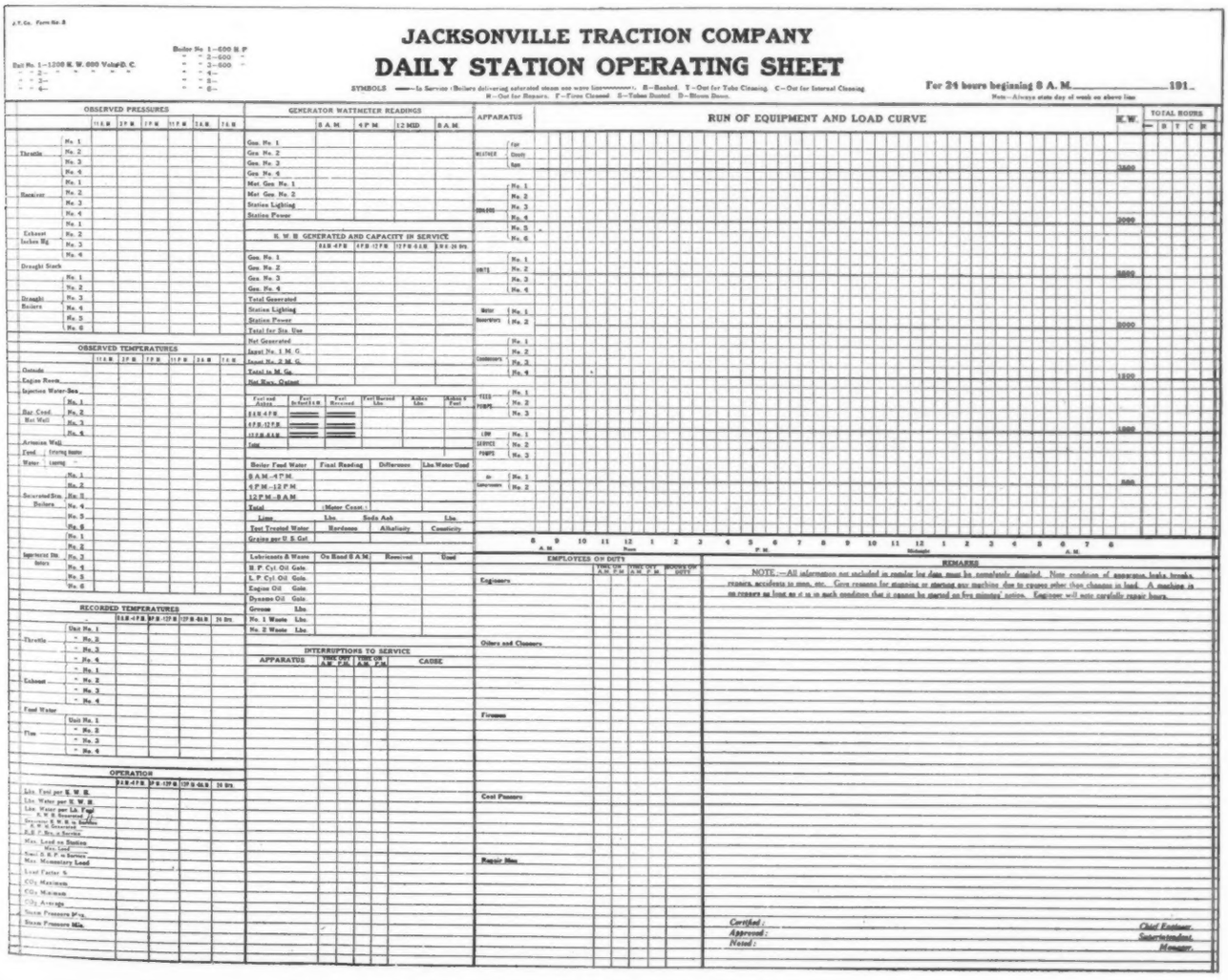
Power Plant of Elgin Watch Factory

The fact that the Elgin Watch Factory at Elgin, Ill., has its own private power plant has made some very interesting "copy" for the advertising manager of their well known product. Recent advertising of the Elgin company gives a description of its large new plant.

Steam is generated in a battery of four boilers which are equipped with self-stoking grates. There are two engines, one of 300 hp. and the other of 750. Direct connected to these engines are three generators. There are also one steam- and one motor-driven exciter, an air compressor and a refrigerating system. The switchboard is heavily equipped and consists of 14 panels.

The electrical power generated is supplied to every room in the factory by motors which move 12,499 ft. of main shafting, 13,747 ft. of countershafting and 73,837 ft. of belting. The lamps lighted throughout the building total to 7000. The exhaust steam is, of course, used to heat the entire establishment. The Elgin plant in every way shows the progressiveness of its owners.—*The Isolated Plant.*



JACKSONVILLE TRACTION COMPANY

DAILY STATION OPERATING SHEET

SYMBOLS —In Service; Boilers delivering saturated steam one wave line———; S—Banked. T—Out for Tube Cleaning. C—Out for Internal Cleaning. R—Out for Repairs. V—Tubes Cleaned. S—Tubes Dusted. B—Blown Down.

For 24 hours beginning 8 A. M. _____ 191_

Note—Always state day of week on above line

OBSERVED PRESSURES

OBSERVED TEMPERATURES

RECORDED TEMPERATURES

OPERATION

GENERATOR WATTMETER READINGS

K. W. H. GENERATED AND CAPACITY IN SERVICE

INTERRUPTIONS TO SERVICE

APPARATUS

RUN OF EQUIPMENT AND LOAD CURVE

K.W.

TOTAL HOURS

EMPLOYEES ON DUTY

REMARKS

NOTE.—All information not included in regular log form, must be completely detailed. Note condition of apparatus, leaks, breaks, repairs, accidents to men, etc. Give reasons for stopping or starting any machine due to causes other than changes in load. A machine is in reserve as long as it is in such condition that it cannot be started on five minutes' notice. Engineer will note carefully repair hours.

Certified:

Approved:

Noted:

Chief Engineer.

Superintendent.

Manager.

FIG. 9. DAILY OPERATING LOG SHEET

Pipe Sizes and Steam Velocities

By C. W. Ham

SYNOPSIS—Discussion of the determining consideration in selecting sizes for high-pressure piping in power stations and velocities of steam. The basis should be a compromise between radiation and friction losses and generally higher than common velocities are allowable. Steam outlets or openings on equipment are not safe guides to proper pipe sizes.

While piping is a small part of the station and was formerly considered relatively unimportant, it has become a leading subject for study in connection with power-station design. There seems to be no fixed basis for the design of high-pressure piping, and, while the subject of pipe sizes and velocities of steam has been much discussed recently, opinions still differ considerably as to what constitutes best practice.

Steam piping both for high-pressure and auxiliary lines, is generally unnecessarily large. Formerly it was thought that piping could not be too large, and as engineers were averse to taking the responsibility for small piping they specified liberal sizes.

If a pipe is too large the radiation loss will be excessive; on the other hand, because of friction, a pipe may be so small as to cause a too great drop in pressure. Pipe diameters should, therefore, be a compromise between the radiation and friction losses. In steam-turbine practice, a drop in pressure of 5 to 10 lb. between boiler and turbine is permissible. Increasing the pipe size reduces friction so little and adds to radiation loss so much, that the tendency lately to adopt smaller pipe and greater steam velocity is justified, both from the operating side and that of first cost. The gain from the operator's standpoint is chiefly in flexibility. This means less strain on the fittings because of easier expansion and contraction, with smaller cost for repairs. Vibration, sometimes resulting from small diameters and high velocities, can be overcome by avoiding too many sharp turns. The tendency toward larger units in power stations and high pressures and superheat requires that the piping be large and of high-grade material, and the cost increases rapidly with the size. For example, a 9-in. high-pressure fitting costs about 25 per cent. more than an 8-in. fitting. Size is, therefore, of considerable importance in the cost of an installation.

The advent of the steam turbine, with high pressure and superheat, revealed the fact that different standards are demanded in pipe diameters. In a steam-engine plant, shocks due to the intermittent demand for steam must be allowed for and the piping has usually been made large enough to act as a reservoir for handling large amounts for short periods. Making the pipes smaller and having a receiver near the engine would be better and is sometimes done. Conditions are different with turbines, because steam is delivered to them steadily. An authority has declared that if, instead of turbines, reciprocating engines were operated, using superheated steam, the pipe line would have to be of approximately 25 per cent. greater area, and, if the reciprocating engines used nonsuperheated steam, it would have to be 40 per cent. larger.

The most marked revolution in the design of steam piping has been in the design of the header. Formerly it was customary, in using the header as a reservoir, to make it equivalent in sectional area to the sum of the areas of the boiler outlets. This often led to absurdly large sizes and low velocities, not only because all the steam from the boilers does not necessarily pass through any one section of the header, but also because the standard boiler outlets have been unnecessarily large, their sizes being governed by shop standards rather than by any fixed velocity. For example, there are 300- and 600-hp. boilers having the same size nozzles. As it has been the custom never to reduce the steam pipe below that called for by the nozzle on the boiler, it can be understood that headers proportioned on that basis frequently led to absurd results. Rarely is it possible to place the header near the prime movers. If this is practicable, the larger header is justified and becomes of value as a receiver. In latest practice, however, the header is made little if any larger than the branch pipes leading from it; the size being governed by the maximum amount of steam passing any one section, just as with other piping.

Important in the design of piping, and the chief factor in fixing the proper size, is the

Velocity of Flow

Until quite recently a steam velocity of 5000 ft. per min. was considered high, and most piping was based upon even lower velocities. The maximum permissible velocities are now quoted by most authorities at from 6000 to 9000 ft. per min., and during heavy overloads for short periods, 10,000 to 12,000 ft. per min. It has been demonstrated that the higher velocities are satisfactory, and that the radiation losses are thereby greatly reduced, especially with highly superheated steam.

In some of the large latest turbine stations the piping size is based on a velocity of approximately 8000 ft. per min., with a pressure drop of 5 to 10 lb. from the boiler to the turbine. This seems to be the velocity sanctioned in the most uptodate work where high pressure and superheat are common. The velocity of exhaust steam ordinarily varies from 20,000 to 30,000 ft. per min., depending on the vacuum carried. On account of the very rapid increase in the volume of steam for slight increases of high vacuum, exhaust steam may, in extreme cases, reach much higher velocities. As the time the peak load is carried is usually short, to keep the pipe sizes down, efficiency might well be sacrified during those periods and extreme velocities employed.

In spite of these higher velocities being advocated by good authorities, many modern power stations do not use the higher velocities. This is partly because builders of boilers and prime movers have made their steam connections ample, generally giving the purchaser the size called for. Many engineers and operators being still prejudiced against small piping, large sizes are specified. The piping is connected up without any reduction, hence the low velocities. For a number of years a certain boiler was operated with an 8-in. pipe leading from it, which was replaced by a 5-in. pipe, giving entirely satisfactory

results. Lately boiler manufacturers have realized that their standard nozzles are too large and are having them reduced. Even then they are governed more by a question of standard than velocity, so the matter of pipe sizes should be considered independently from the sizes of nozzles proposed by boiler manufacturers.

The sizes of standard steam openings in power-plant units are based upon some assumed condition of the steam at a moderate steam velocity. Then for the sake of standardization, a definite size of opening is assigned to cover a certain range in size of units. Openings are thus the result of a practical compromise to suit numerous conditions, consequently it is not reasonable to assume that, in specific cases, the piping should be made to conform to the standard openings.

Comments on Table

In the accompanying table are given the size of main steam piping, velocities of steam, and drop in pressure in a number of modern steam-turbine stations selected at random. The velocity quoted is based on the maximum continuous output capacity of the plant; that is, the velocities that exist in the piping system when the units are operating at the load that can be maintained continuously. This average condition would ordinarily mean about 50 per cent. overload on the boiler and full load on the turbine. What are usually called extreme velocities may be estimated on the basis of 100 per cent. overload on the boiler and 50 per cent. overload on the turbine. It would be unfair to base them on the very large momentary overloads which are not maintained for any considerable time.

TABLE SHOWING SIZE OF PIPING, VELOCITIES OF STEAM, AND DROP IN PRESSURE IN 12 STEAM-TURBINE POWER PLANTS UNDER NORMAL WORKING CONDITIONS

Station	Rating of Units						Steam Consumption of Turbine,	Boiler Steam Pipe		Header		Turbine Steam Pipe		
No.	Normal Capacity in Kw.	Boiler Hp.	Turbine Kw.	Steam Pressure Lb. per Sq.in.	Superheat, Deg. F.	Feed Water, Temp. Deg. F.	Vacuum, Inches Mercury	Lb. per Kw.-hr.	Dia. Boiler Nozzle	Dia. In.	Vel., Ft. per Min.	Dia. In.	Vel., Ft. per Min.	Dia., In.	Vel., Ft. per Min.	Drop in Pressure, Lb. per Sq.in.
1	15,000	625	5000	200	0	210	28.0	17.0	6	6	5600	8	6,300	9	7000	10
2	6,000	600	3000	200	100	200	28.0	14.7	8	10	3750	12	6,750	10	3500	10
3	11,000	600	1500	175	100	210	29.0	20.0	8	8	4200	12	11,400	8	4300	10
4	20,000	600	5000	175	150	205	29.25	17.0	7	7	6000	16	7,500	12	5900	10
5	2,000	500	1000	175	0	265	28.0	21.0	8	8	3300	15	4,800	7	3400	5
6	30,000	300	3500	175	125	200	27.0	16.0	4	4	8700	20	7,700	12	3700	5
7	5,000	600	2500	175	125	210	27.0	15.8	6	6	7650	10	5,400	10	3700	10
8	1,000	400	800	160	100	205	28.0	18.0	7	7	4200	12	4,200	7	3250	5
9	3,000	585	1500	160	175	212	28.5	22.9	6	6	9000	8	5,000	8	6200	7.5
10	8,000	500	2000	200	200	210	29.0	18.5	8	8	4000	12	6,300	9	4250	5
11	1,500	150	500	145	0	196	28.0	21.6	6	6	1900	12	4,000	5	4100	5
12	8,000	190	750	160	125	200	28.0	16.7	4	4	7900	10	7,900	4.5	7900	10

In no case does the drop in pressure exceed 10 lb. Any greater drop during temporary overloads could be overcome if necessary, as with modern boilers it does not cost must to increase the steam pressure sufficiently to compensate for the drop due to high velocities.

Examination of the table will show that, although high pressures and superheat are employed, most of the piping systems have been laid out along much the same lines as in previous practice. The velocities are low and vary widely, and there is no uniformity, even in the same system. For example, in Station No. 3, the velocities in the boiler and turbine pipes are low, while that in the header is extremely high. Plainly, velocities were not considered in the design; the piping having been simply made the same size as the nozzles on the machines. However, the tendency toward the smaller header is strikingly brought out. In no case has a reduction been made at the nozzle.

In Station No. 2 the boiler pipe has been actually increased. In the examples given here where the piping system is based upon high velocities, the designer has specified small steam openings for the units, which can nearly always be done, instead of using a reduction fitting.

In Station No. 1, instead of working up the piping plans, as usual from the boiler nozzles toward the generating apparatus, the designer started at the turbine where the steam is to be used and worked toward the boiler, having the boiler manufacturer put on nozzles to suit the piping arrangement. No particular attention was paid to velocity in any particular part of the line. The turbine opening was of such size as to give a high velocity in the turbine pipe. The velocity in the rest of the system is somewhat lower, but, on the whole, high as compared with many other stations. This is a typically modern station, and the piping is noteworthy in that it was one of the first installations recognizing the fact that turbines demand smaller pipe diameters.

In No. 4 the designer allowed for superheated steam permitting higher velocities than with saturated steam. there being considerably less friction, and the volume of steam at 175 lb. pressure and 150 deg. superheat being about 30 per cent. greater than saturated steam at the same pressure. The table shows the velocities to be fairly uniform, in the system, and considerably above the average. Station No. 6 is typical of the use of high velocities and the piping in this plant is giving entire satisfaction.

The striking feature of Station No. 12 is that it is the only one of the group in which velocity was made the basis for the design of the entire piping system. Here the velocity is high, 7900 ft. per min., and uniform throughout. This plant is of very recent construction, is operating satisfactorily, and the design of the piping system may be taken as typical of the very latest and best practice.

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There is a strong tendency now to dispense with a lot of countershafting formerly used in driving woodworking machines, and it is the electric motor and the high-speed lineshaft that are doing it. It is easy to understand the high speed and light sizes in connection with elctric moors, but even among those not using motors there is the same tendency to use lighter lineshafting and run it at higher speed. It helps reduce the friction load by making the shafting and pulleys lighter, the belts smaller and the strain or pull less.—"Woodworker."

❖

There are between 9,000 and 10,000 passenger elevators and 12,000 freight lifts in Manhattan alone which carry about 6,500,000 persons each day. In the six years from 1903 to 1908 more than 4,000 elevators of all makes were installed and in the period 1903 to 1907 there was an increase of rentable area of 23,870,006 sq.ft., or about 550 acres, of which 6,772,006 sq.ft. were business buildings, 10,965,835 sq. ft. were lofts and stores and 3,178,243 sq.ft. were in factories.

Peculiar Explosion of Locomotive Boiler

SYNOPSIS—A locomotive boiler explodes while standing on a siding, killing the engineer and wounding the fireman. The boiler, intact, is blown 100 ft. away. The curvature of the crown-sheet is reversed and the stay-bolts are not even bent. Low water undoubtedly the cause of the explosion.

While standing on a siding at Handley, Tex., Mar. 30, the boiler of engine No. 325 of the Texas & Pacific R.R. exploded, instantly killing the engineer and wounding the fireman and another workman.

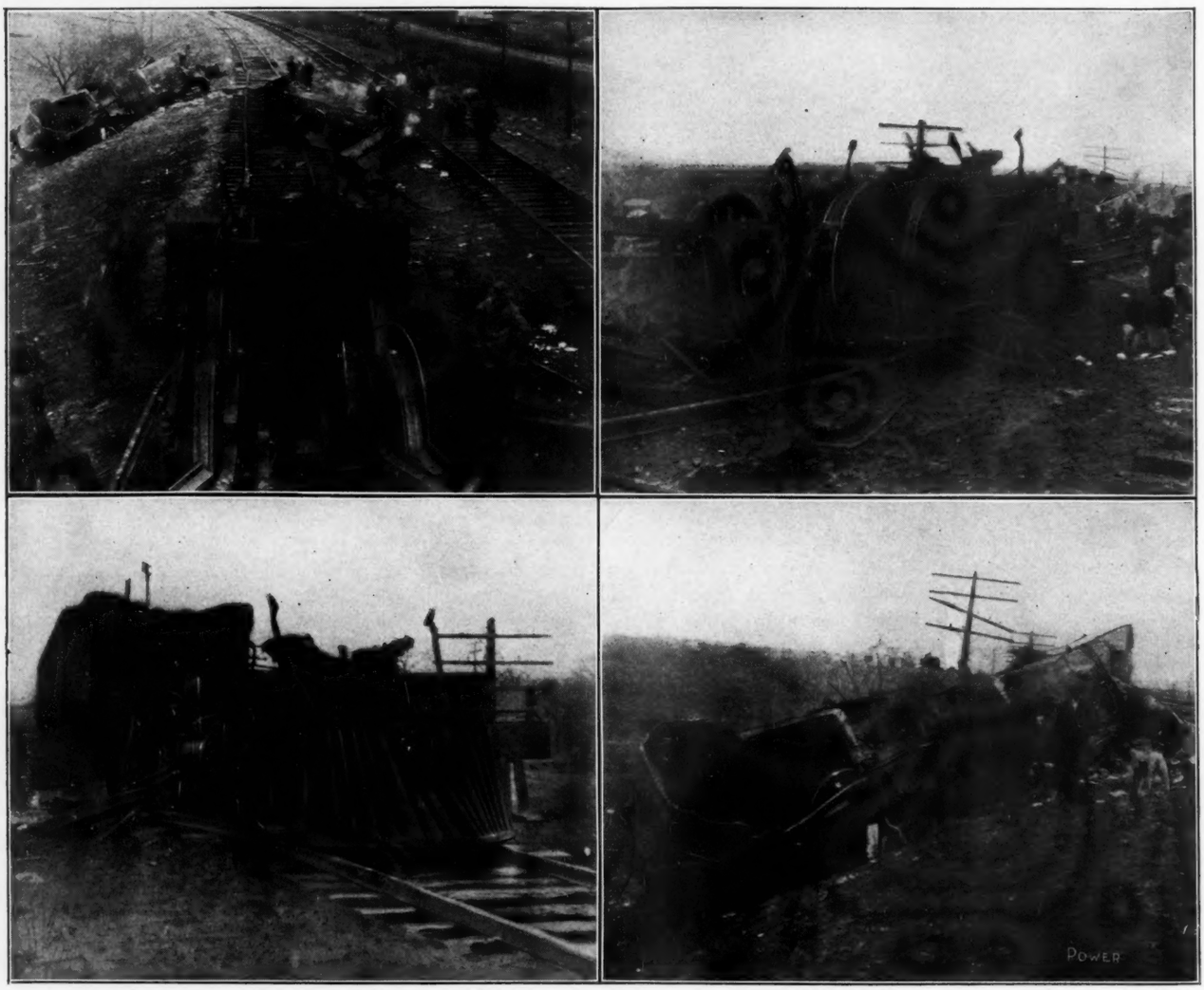


FIG. 1 FIG. 2 FIG. 3 FIG. 4 DAMAGED TRUCK AND BOILER

As shown in Fig. 1, the boiler was blown completely off the trucks, landing on the track about 100 ft. ahead and finally coming to rest in the position shown. How severely the trucks and mechanism carried thereon were damaged may be seen in Fig. 2. Some idea of the force of the explosion may be gained by a glance at the severed driver in this illustration. The rod connecting this driver remained intact at the head end, and acted as a pivot around which the driver was caused to rotate through an angle of a little over 90 deg.

The damage to the trucks was undoubtedly done by the recoil action as the boiler leaped forward. The tender and front end of the locomotive were but slightly damaged (Fig. 3), which shows that the force was greatest at the rear and acted downward almost entirely. The track under the truck was also torn from the ties and bent badly, as shown in Fig. 2. This was evidently caused by the movement of the disconnected driver as it was thrown outward.

The crown-sheet was ripped almost entirely from the boiler, as shown in Figs. 4 and 5. The curvature of the crown-sheet was reversed as it was blown down through the firebox. From the smoothness of the curvature it would seem that the sheet was very hot when the explosion occurred; otherwise the bottom of the sheet would have bent more irregularly. That part of the sheet immediately over the grates was discolored, showing that it did heat considerably. Another thing that indicates that the sheet was quite hot is the manner in which it parted from the stay-bolts, none of which were torn from the sides or top of the firebox.

It looks as though the heads of these bolts became red hot, thus allowing the crown-sheet to slip over the soft-

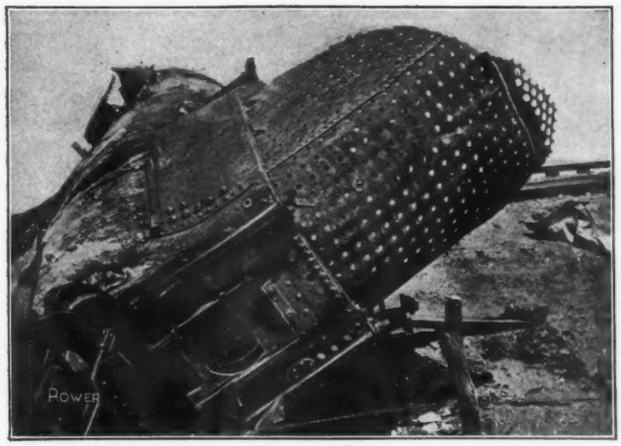


FIG. 5. CROWN-SHEET; CURVATURE REVERSED

FIG. 6. FRONT END OF BOILER

ened bolt heads without cracking the sheet or disturbing the other ends of the bolts. Another interesting peculiarity is that hardly any, if any at all, of the bolts were even bent. The tubes were damaged but little. The bent sheets at the front end, as shown in Fig. 6, were damaged chiefly by the boiler falling on that end as it landed on the tracks after having turned over a couple of times in the air.

Examination of the firebox showed that the boiler was coated with scale, but not unusually so. Only one gage-cock could be found and that was clear and in working condition.

There was no indication of heating at the place where the crown-sheet ripped, but its discoloration in the center indicates low water. As far as is known the safety valve was in working order.

❖ ❖

Slinging and Making Hitches*

BY JOHN RIDDELL†

SYNOPSIS—Suggestions for the avoidance of accidents when handling heavy machinery with a crane. A number of hitches are also illustrated.

❖

There is a great difference in ropes and slings used for hoisting. The wear in ropes can always be seen by the strands becoming frayed, loose or cut; whereas a chain, outside of a few bruises, will not show any signs of weakness, although actually it may be full of small cracks which cannot be seen by the naked eye, or it may be crystallized by long use. A chain under these conditions rapidly becomes weaker with each lift, until it finally gives way.

Suitable racks should be provided for hanging chains and slings when not in actual use. These slings should be inspected frequently to detect weakness, sorting out the bad ones and having them repaired.

There are many varieties of hitches and many kinds of knots. Some are useful, others are ornamental; only the useful kind will be considered. A general description is given of the standard hooks, eyes, clevices, etc., used in general practice. Some knots and hitches are shown which are used in special cases, but which are not intended for everyday use. They are useful, however, for riggers, millwrights and others handling special machinery and materials, and should be used only by men competent in such work.

A wire cable sling should never be used singly when hooked by a spliced eye. When the weight is sufficient the cable is likely to untwist, thus allowing the splices to open and slip. Such slings should always be used double, and where sharp corners or rough castings exist the cable should be protected by pads.

In using slings of any kind, especially rope, care should be taken to see that one rope does not lie on top of the other, as this will prevent proper equalization, putting undue strain on the outer rope. Often when a rope sling is used double, the ends are passed through the doubled part, as when placed around a casting; and, unless this is done carefully, instead of having the strength of two parts of a rope, as supposed, it can be so slipped around the piece being lifted, as to actually have the strength of only one part.

SUDDEN STOPPAGE OF LOAD

Before lifting heavy loads by means of a crane the crane brakes should always be tested to see that they are in good condition and will hold. Care must be used when lowering loads, to limit the speed, which should not exceed the hoisting speed of the crane for the same load. Particular care must be taken to apply the brakes gradually when bringing the load to rest. The ordinary hoisting speed for a 30-ton motor-operated crane is about 18 ft. per min., and for a 50-ton crane about 12 ft. per min. with the rated load. Sudden stopping at such speeds may double the stress on the slings and crane. This point cannot be emphasized too strongly, as serious accidents have resulted from the sudden stopping of cranes while the load was being lowered.

When a weight is lifted by two or more slings connected to the crane hook and making an angle with each other,

*From an article in the "General Electric Review."

†Mechanical superintendent, Schenectady Works, General Electric Co.

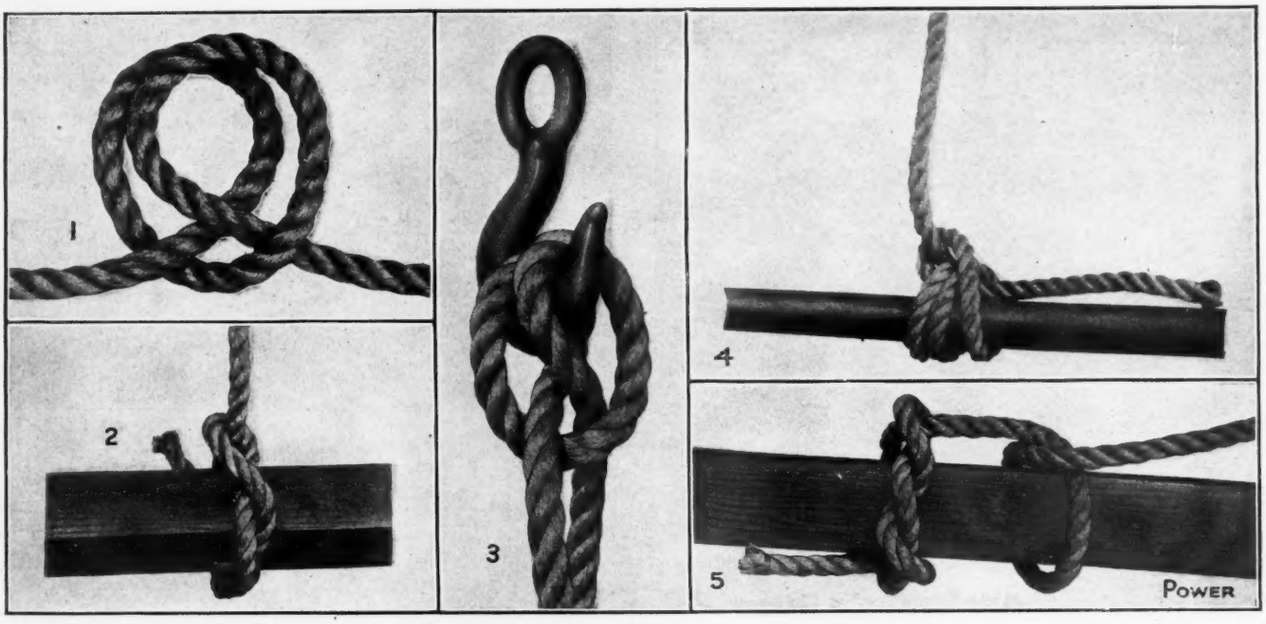


Fig. 1. Clove or double half hitch. Fig. 2. Timber hitch. Fig. 3. Clove or double half hitch adapted for hauling. Fig. 4. Studding sail hitch, useful in hoisting timber. Fig. 5. Timber and half hitch, useful in hoisting shafts or timbers in vertical position.

the increase in the stress of the individual slings must be considered. On account of this angle between the two sets of slings the stress on each set is greater than half the total load, and increases very rapidly as the angle between the sling and the work is decreased. An angle of 45 deg. between the sling and the work makes the stress in each sling three-fourths of the total weight, and the collapsing force between the two points of attachment to the work is equal to half the weight. This collapsing force acts in a direct line between the two points of attachment. If the work is ring-shaped, it would tend to deform the ring.

A spreader of sufficient stiffness should be used between these two points to resist this collapsing force. It will be seen that eye-bolts are not suitable for attaching the slings to the work unless a spreader is used to relieve them of this side pull, which would put a heavy bending mo-

TABLE 1. SAFE LOADS FOR EYE-BOLTS

	Inches A	Inches B	Inches C	Safe Load, Lb.
Drop-forged steel	¼	1½	7/16	1,100
	5/16	1 9/16	11/16	1,500
	⅜	1 11/16	¾	1,800
	½	1 11/16	¾	2,800
	½	1 11/16	¾	3,900
	¾	1 11/16	¾	5,100
	1	2 1/16	1⅛	8,400
	1¼	2 5/16	1 5/16	12,200
	1½	2 9/16	1⅜	16,500
	1¾	3 1/16	1½	21,800
	2	3 1/16	1½	10,000
D.B.G. Iron E.L., 28,000 lb. per sq.in., welded	1½	3	1½	11,000
	1¾	4	1½	14,000
	2	5	1¾	16,000
	2¼	6	2	

TABLE 2. WEIGHTS OF VARIOUS MATERIALS

Material	Weight per Cu.Ft., Lb.	Weight per Cu.In., Lb.
Cast iron	450	0.26
Steel	489	0.28
Copper	552	0.32
Lead	709	0.41
Wood		
Ash	45	
Pine	38	
Concrete	155	
Stone	180	
Earth	72 to 110	
Brick	100 to 150	
Mortar	100	
Marble	180	

Shafts

Diameter, In.	Weight of Shafting in Lb. per Lineal Ft.
6	95
8	169
10	264
12	368
14	517
16	676

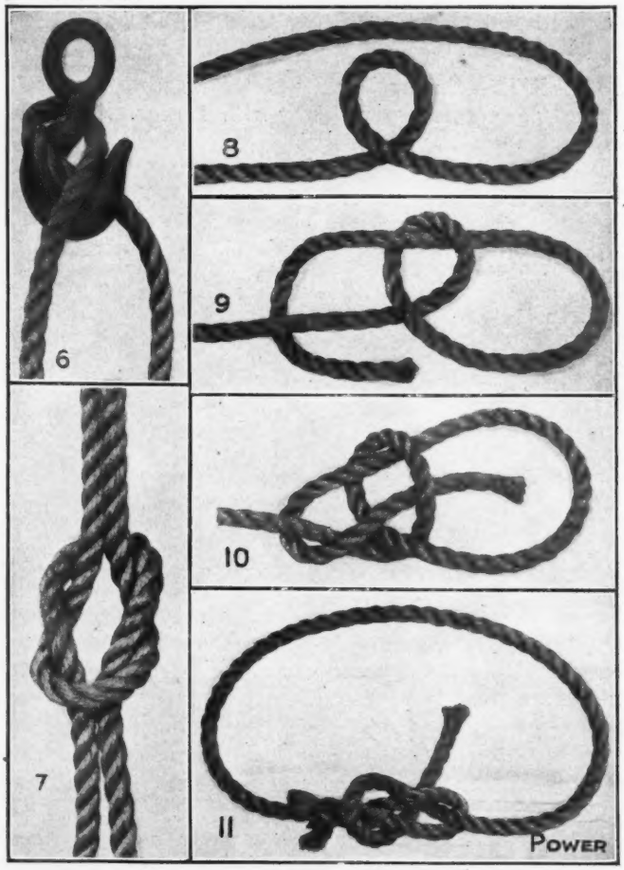


Fig. 6. Blackwall hitch, especially useful for hauling material on the level. Fig. 7. Square or reef knot used only for joining two ropes together. Figs. 8, 9 and 10. Steps in making a bowline knot. Fig. 11. Sheet bend in eye, generally used for an adjustable sling.

ment on the shank of the bolt. Reducing the angle between the sling and the work to 30 deg. makes the stress in each sling equal to the weight, and the collapsing force is also equal to the total weight. Such a small angle should never be used if avoidable.

Safe Loads on Ropes and Chains

When it is necessary to use eye-bolts for lifting loads, no greater stress should be allowed than given in Table 1, which shows the safe load in pounds for bolts up to and including 2¼ in. in diameter. It should be noted that the values given are correct only when the pull is in the direction of the arrow shown in Fig. 14, and when the bolt is in good condition.

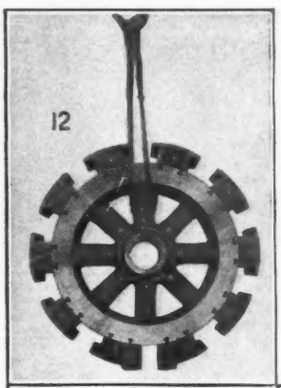
Eye-bolts should never be painted when used for miscellaneous lifting, as paint is apt to cover up flaws. They should be tested occasionally by tapping gently with a hammer, but not sufficient to bend or to otherwise injure them. If they do not impart a good ring they may fit too loosely in the hole, or there may be a flaw.

Safe Load on Ropes and Chains

Table 3 gives the safe loads which may be put on manila rope, wire cables, and chains. The figures are in tons of 2000 lb. each. The loads for manila rope should be used only when the rope is in fairly good condition; when badly chafed or worn the load should be reduced.

As there are many kinds of material to handle, a short list of the weights of the various materials is given in Table 2. The weight of shafts are given per lineal foot.

A wood or lag screw, when made in the form of an eye-bolt, should never be used for hanging any hoisting tackle. Wherever possible the safest way to hang such tackle is by passing the shank of an eye-bolt through the floor or beam, properly protecting the wood by a large plate washer and nut. It frequently happens that a chain or rope sling can be used by passing it over a properly secured timber.



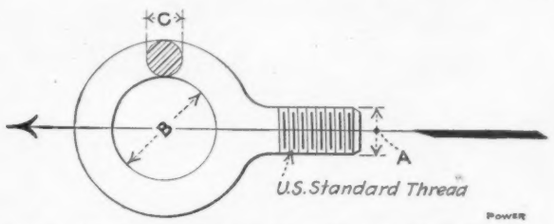
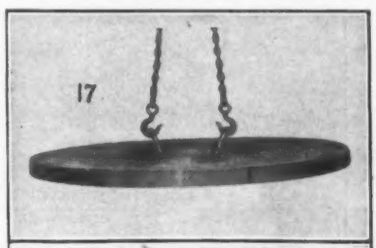
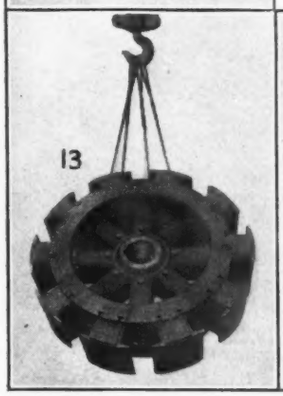


Fig. 14. Proportions of Eye-Bolts (See Table 1)





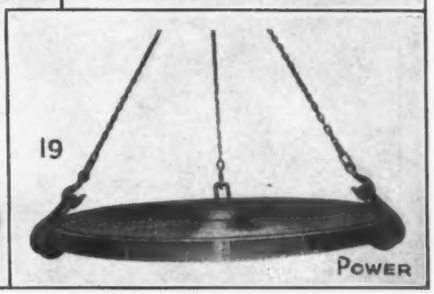


Fig. 12. Improper method of making a hitch for turning revolving fields with two slings. Fig. 13. Proper method of making hitch for turning revolving fields. Figs. 15 and 16. Wrong and right ways of making a hitch. Figs. 17 and 18. Wrong and right use of double hooks. Fig. 19. Three double hooks—preferable where possible.

TABLE 3. SAFE LOADS ON ROPES AND CHAINS

Manila Rope, Safe Load in Tons				Wire Cable, Safe Load in Tons				Chains, Safe Load in Tons			
Dia. of Rope, In.	Single Rope	Two Part	Four Part	Diam. of Cable, In.		Two Part	Four Part	Diam. of Chain, In.	Single Chain	Two Part	Four Part
¼	¼	¼	½	¼	1	2	3½	¼	¼	½	1½
⅜	½	½	1	⅜	1¼	3½	6½	⅜	1	1½	3
½	¾	¾	1¼	½	2½	4½	9	½	2	3½	6
⅝	¾	1	2	⅝	3¼	6	12	⅝	3	5	9
1	1	1½	2½	1	4	8	16	¾	5	9	15
1¼	1	2	3	1¼	6	12	24	⅞	6	10½	18
1½	1½	2½	4	1½	10	19	36	1	8	14	24
1¾	2	4	6	1¾	13	25	48	1¼	11	19	33
2	2½	5	8	2	16	32	60	1½	13	23	39
2¼	3½	6½	11					1¾	18	32	54
2½	4½	8	13								

Other defects besides those in lifting apparatus will occasionally be discovered, such as a cracked arm of a flywheel, or other similar piece. If this defect is discovered by the person originally handling the piece, he should call his superior's attention to it immediately upon making such discovery. Those engaged in this important work should also have some idea of the strength of materials. They should know how the strains will be set

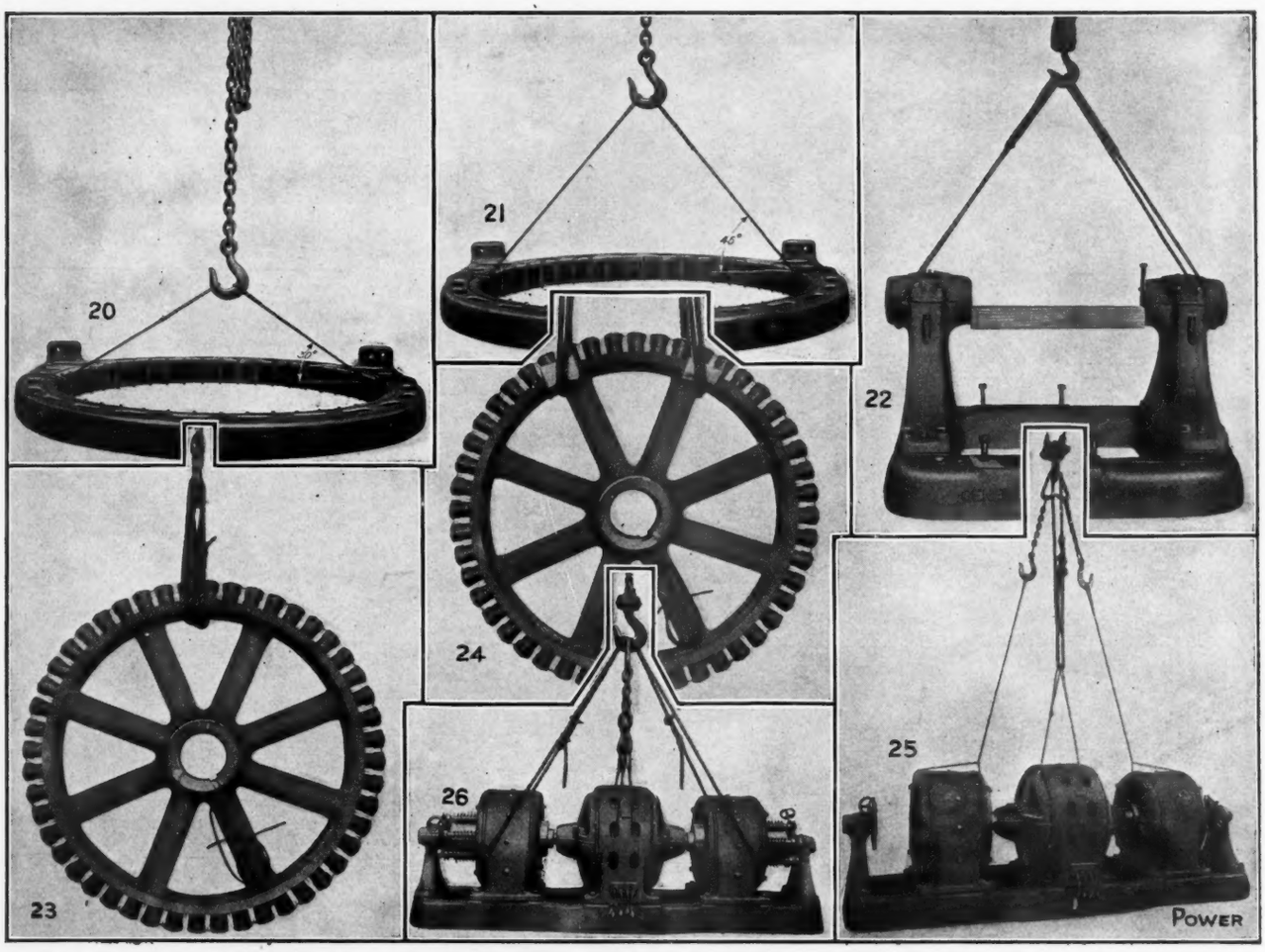


Fig. 20. 30-deg. angle sling (wrong way). Fig. 21. 45-deg. angle sling (right way). Fig. 22. Lifting a base with standards with provision for lateral strains. Fig. 23. Lifting revolving field (wrong way). Fig. 24. Lifting revolving field (right way). Figs. 25 and 26. Wrong and right ways of lifting motor-generator sets.

up in such materials, and also how to apply slings for lifting, as here illustrated. They should know that using too small an angle on the slings, as in the case of a field ring, would tend to pull the sides together; and that, in the case of a revolving field where the sling is applied between a pair of arms instead of around adjacent arms, the tendency would be to break out a portion of the ring. This is shown in Figs. 23 and 24.

A Word for the Reciprocating Engine

In discussing a paper read before the Hannover section of the Verein deutscher Ingenieure, by H. Klippe, upon the steam turbine, one of the participants took up the cudgel for the reciprocating engine.

The turbine works with a 90 per cent. vacuum; the engine with from 85 to 90. A 400-hp. reciprocating engine calls for 60 cu.m. of cooling water per hour for the condenser; the turbine needs 200 to get the extra 5 per cent. of vacuum. Hence, the turbine needs more space for the condensers, and it is not a fact that the turbine with its auxiliaries requires less space than a reciprocating engine of equal capacity.

The steam consumption of the reciprocating engine he maintained to be lower. In England a 1000-hp. Parsons turbine calls for 8.1 to 9.14 kg. (17.8 to 20.1 lb.) of steam per kilowatt-hour, and in Elberfeld Schröter reports for one of the same power 8.96 to 9.7 kg. (19.7 to 21.34 lb.). The same engines of the Hannover Electric Station at Herrenhausen are of about the same power but require only 7.5 to 8.2 kg. (16.5 to 18 lb.). Stodola rates the consumption of a steam turbine of 125 kw. at 11.57 kg. (25.45 lb.); one of 232 kw. at 9.93 kg. (21.84 lb.); of 497 kw. at 10.89 kg. (23.95 lb.), while the Hannoversche Maschinenbau A-G guarantees for engines of these capacities under the same conditions, 9.5, 9.2 and 9.1 kg. (20.9, 20.24 and 20.02 lb.). With the reciprocating steam engine, the work expended on the condenser is only 3 per cent.; with the turbine, 5 per cent.

Coal in South Africa

An estimate of the coal resources of the Union of South Africa, based upon geological surveys, yet only approximate, places the aggregate quantity at 55 billion tons. Most of the coal, about 36 billion tons, it would appear, is in the Transvaal, while in Natal the given quantity is 9400 million tons. The remainder, equal to say 9600 million tons, is distributed among the other provinces. The Union produced over 7½ million tons in 1911.—*Coal Age.*

Cases of pitting tubes in boilers are said to have been cured by connecting the inlet of the feed pipe to the blowoff pipe with a ½-in. copper bond.

ELECTRICAL DEPARTMENT

Alternator Testing

By F. S. Barton

All the losses in electrical machinery appear as heat and due to imperfect radiating properties, some of the heat is retained in the machine, which raises its temperature. The smaller a machine for the same amount of work the greater will be the proportionate losses and consequently the greater the heating. Competition forces manufacturers to build machines as close to the specified temperature rise as they can. The machine must do the work, yet be produced as reasonably as possible, which means that the amount of stock must be reduced till the temperature rise is a few degrees below that specified.

Temperature rise will be found to lie mainly between 35 and 45 deg. C. above the existing room temperature for runs at normal or rated full load. It is customary to specify a higher temperature for a run of two hours at 125 per cent. load. When specifying the allowable rise, one must not forget this is above room temperature, which in a generating room is variable. It is best to call for a comparatively small temperature rise, although it usually necessitates a somewhat more expensive machine.

It is now customary to measure temperatures of all parts of electrical machinery both by thermometers and by the rise-of-resistance method. The former method is inferior to the latter because the outer coils in contact with cooling mediums show a lower temperature than the interior windings. One should always specify that the temperature rise be determined by the rise-of-resistance method and checked by the thermometric method.

When laying out an alternating-current station it is necessary to know the amount of field current required to produce normal voltage at no load, full load and overloads for unity power factor and often for lower power factors. This will determine the size of field cables necessary, also the size of the exciters. A very useful curve to make for obtaining this information is known as a "saturation curve"; this has the general shape shown in Fig. 1 and is plotted between armature volts as ordinates and field amperes as abscissas, and is ordinarily taken with the armature open-circuited. This curve is so called because it shows the relation between the degree of magnetic saturation of the iron and the corresponding field excitation, the armature voltage being proportional to the magnetic flux at no load. As the voltage is also proportional to the speed it is essential that the speed be held constant throughout this test.

In conjunction with this curve a running impedance curve should be taken. This is plotted between armature amperes and field amperes, the alternator being short-circuited during the test. The curve takes the form of a straight line, as in Fig. 2, and the resulting armature currents lie considerably below the value to which they would rise momentarily if a short-circuit were thrown on the machine while running open-circuited with the same strength of field excitation. It is customary to hold the speed constant during this test, but it is not so necessary as in the case of the saturation curve, because alternating current is directly proportional to the voltage and inversely proportional to the impedance as expressed by

$$I = \frac{E}{\sqrt{R^2 + (2\pi f L)^2}}$$

Considering the expression for impedance, which is $\sqrt{R^2 + (2\pi f L)^2}$, it is remembered that the machine is short-circuited during this test and the resistance R is, therefore, practically negligible. Hence the impedance becomes $2\pi f L$ (or reactance only) and

$$I = \frac{E}{2\pi f L} = K\frac{E}{f}$$

In this expression, E (the voltage) is proportional to the speed as is also f (the frequency). The numerator and denominator both being proportional to the speed, any change of speed will not affect the value of the fraction, which is equal to I (the current). Actual experiment

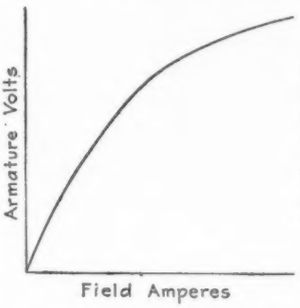


Fig. 1. Saturation Curve

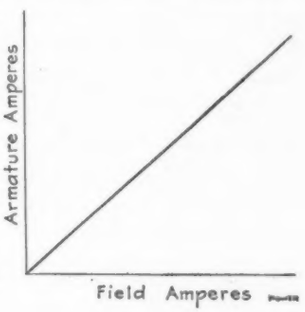


Fig. 2. Impedance Curve

bears out this interesting fact, for the current will hold up to normal till the machine is within a few revolutions of stopping.

Voltage Regulation

These two curves are useful in determining the voltage regulation on large alternators when it is impracticable to load them, actually. Generator regulation may be defined as the percentage change from normal voltage when full-load noninductive current is suddenly thrown off, holding the field excitation and speed the same. In most alternators this is about 6 or 8 per cent., but the smaller the regulation range, the larger and costlier the machine. Sometimes regulation is called for at 80 or 90 per cent. power factor; this is taken lagging, as a leading power factor would cause a drop in voltage if the load were thrown off. The present tendency, however, is not to lay so much stress on regulation, because of the admirable automatic regulation by the Tirrell regulator.

Efficiency

Efficiency is the ratio of the useful output to the total input, or letting

E = Total energy used in driving the generator;
E' = Energy available at terminals of the machine;
e = Total losses.

$$Efficiency = \frac{E'}{E} = \frac{E'}{E' + e} = \frac{E - e}{E}$$

The efficiency of ordinary alternators varies from 90 to 95 per cent. The losses consist of windage, bearing and brush friction, iron losses and copper losses. Methods of measuring and separating these will be discussed later.

Customers are more and more appreciating the fact that, while a short-circuit is not a normal condition, yet

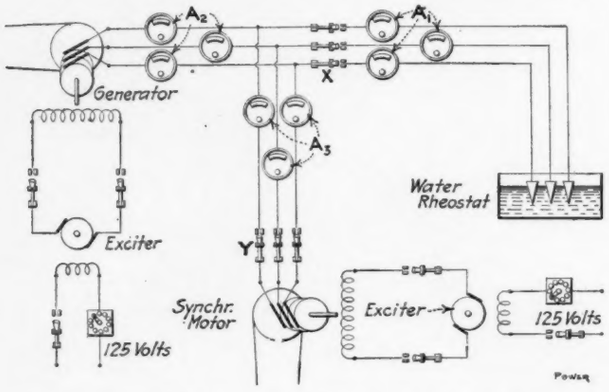


FIG. 3. TESTING ALTERNATOR BY MEANS OF SYNCHRONOUS MOTOR AND WATER RHEOSTAT

it may happen in any well ordered plant and the system to be operative must be able to withstand this.

HEAT RUN

Assume now that a representative is at the factory ready to inspect the alternator which is to be tested for his approval. He finds, if the size is small enough, that it is arranged to be driven at full load by some source of power whose speed can be held constant. While preparations are being made to commence the heat run, the inspector should look the machine over carefully for mechanical defects or undesirable construction. Meanwhile thermometers are being put on all important stationary parts; also several are hung nearby to get the room temperature. The machine should have stood at least 24 hr. so that it will have a consistent and uniform temperature in all its parts which should be at or near the room temperature. After carefully noting the field and armature temperatures by means of two or three thermometers, the resistances of both are measured and recorded. The heat test is now started at rated full-load current and normal voltage and speed. Records should be kept of armature volts, armature amperes, field volts and field amperes as well as the speed. Also the temperature of the field by "rise of resistance" should be calculated in connection with each set of readings, as follows:

Let
T_c = Temperature of field by thermometer when cold, degrees Centrigrade;
R_c = Corresponding resistance;
T_h = Temperature of field to be determined (hot), degrees Centigrade;
R_h = Corresponding resistance.

Then

$$\frac{T_h + 238}{T_c + 238} = \frac{R_h}{R_c}$$

To find the temperature of the field, it is necessary only to measure the current and voltage of the field, calculate the resistance and substitute in the foregoing equation. For instance, suppose that before starting the resistance was 0.9 ohm and the temperature of the field at that time was 30 deg. C. At some time during the run it is found that the field resistance has risen to one ohm. Then the temperature would be:

$$\frac{T_h + 238}{30 + 238} = \frac{1}{0.9}$$

whence,

$$T_h = \frac{30 + 238}{0.9} - 238 = 59.8° \ C.$$

The test is continued till all parts show a constant temperature rise and no longer continue to increase. This usually requires from 4 to 6 hr. The machine is then shut down and thermometers are put on all moving parts quickly and the maximum temperatures are recorded. Meantime the field and armature resistances are being carefully measured, and from the hot and cold readings the temperatures are calculated and compared with the thermometer readings.

Perhaps the simplest and most usual way of securing a specified power factor for a power-factor heat run is by the use of a synchronous motor running at no load on the line and in parallel with the rheostat load. The field of this motor can be varied to secure any power factor desired.

Assume that a three-phase, 200-kw., 2300-volt alternator is to be tested at full load, 80 per cent. power factor. This would probably be connected to water rheostats for load and to a similar machine of the same frequency and voltage (in parallel with the rheostats) to be run as a synchronous motor to furnish the required power factor. Fig. 3 shows a diagram of the arrangement.

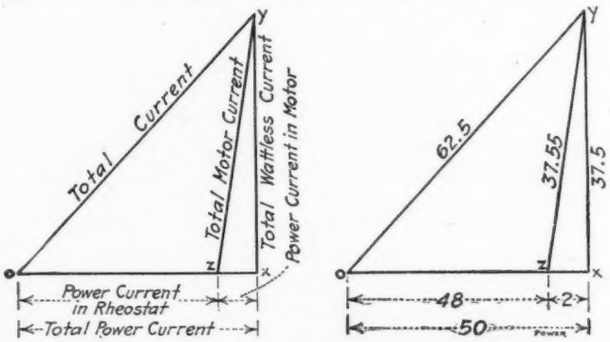


FIG. 4. CURRENT VALUES DETERMINED GRAPHICALLY

The normal generator current at unity power factor is:

$$I = \frac{W}{V \times \sqrt{3}} = \frac{200{,}000}{2300 \times 1.732} = 50.2$$

or 50 amp. (for convenience). This is the current that is necessary to develop 200 kw. at unity power factor at 2300 volts and is represented by ox in the current triangle in Fig. 4. But when running at 80 per cent. power factor, the armature current will be increased, due to the vectoral addition of wattless current; hence the total current will be $50 \div 0.8 = 62.5$, which is represented by oy. The wattless component of the current is xy, which equals

$$\sqrt{62.5^2 - 50^2} = \sqrt{3906.25 - 2500} = 37.5 \ amp.$$

The test is now ready to be started, and a good way to bring the synchronous motor up to speed is outlined be-

low. Close the switches at *Y* (Fig. 3), leaving those at *X* open. Now put approximately normal field excitation on both machines and start the generator; this will bring up the motor in phase with the generator and avoid the necessity of synchronizing.

The first thing to do is to take a curve on the synchronous motor to determine its smallest input current. This is plotted between armature amperes and field amperes and has the general appearance shown in Fig. 5. Corresponding with no field on the motor is the large armature current at *y*. This gradually decreases as the field current is increased until it becomes a minimum at *b*, after which it will increase again with any further increase of field excitation. A number of points should be taken close together near *b* to determine the value of *cb* accurately. This is the minimum armature current necessary to run the synchronous motor and it is all power current; that is, current in phase with the voltage, and any addition to this is wattless. In other words, it is the current necessary at unity power factor to overcome the friction and other losses of the motor. Referring to Fig. 5, of the current *ez*, *eh* is power current and *hz* is the addition caused by the wattless current. All the wattless-current values to the left of *abc* (with an under-excited field) are lagging behind the voltage and those to the right, caused by an over-excited field, are leading.

Since *cb* is the power current necessary to run the motor light, this will constitute a part of the power current of the generator. On the triangle of currents, Fig. 4, lay off *xz* equal to this amount. Assume it to be 2 amp. This brings us to the point of calculating the total current that will be taken by the synchronous motor when producing an 80 per cent. power factor in the generator load. The total motor current would be *xy* if no power were necessary to overcome the friction, windage and other losses; but this is combined with the motor power current and produces the total motor current

$$yz = \sqrt{xz^2 + xy^2}$$

This figures 37.55, which is not much larger than the wattless current *xy*.

Manifestly, the current flowing in the water rheostats is $oz = ox - zx = 48$ amp. In other words, the 50 amp. total generator power current is composed of 2 amp., used to drive the motor and 48 amp. absorbed by water rheostats.

In making the heat run, at 80 per cent. power factor and full load, one man holds the synchronous-motor excitation at the value which was found to give the minimum motor current. The switches at *X*, Fig. 3, are now closed and the resistance in the water rheostats is cut down till the line current equals that corresponding to total power. The ammeters will then read 48 amp., at A_1, Fig. 3; 50 amp. at A_2 and 2 amp. at A_3. It should be noted that, at present, these currents are all at 100 per cent. power factor. One man should hold a current of 48 amp. on meters A_1 from now on till the end of the run, by adjusting the water rheostats when necessary. The synchronous-motor field is next weakened until the total current, read at A_2, is increased to 62.5 amp. The prescribed conditions, shown diagrammatically in Fig. 4, are now established and the meters at A_3 (Fig. 3) should read 37.55 amp. as a check.

If a regulation test is desired it should be done immediately after the heat run, while the machine is warm. This test has been described elsewhere and being simple it would be superfluous to describe it again here.

Very often it occurs that the machine is too large to be loaded fully on the testing floor. Under such conditions it is necessary to resort to compromise tests. These consist of an open-circuit and a short-circuit heat run.

Saturation and running impedance curves should be taken immediately previous to the open- and short-circuit runs respectively. The manufacturers specify some percentage above the normal voltage to be held constant for the open-circuit run and likewise some percentage excess over the normal current for the short-circuit run.

A better way to ascertain the excitation to hold during the open-circuit heat run is to determine the regulation by the use of the saturation and impedance curves. Suppose the excitation necessary to produce normal voltage at no load, according to the saturation curve, is i_1, and from the impedance curve the excitation to give normal armature current is i_2. Then the excitation current necessary to maintain normal voltage at full load is obtained by combining these two values at right angles:

$$I = \sqrt{(i_1)^2 + (i_2)^2}$$

This is the field current that should be held during the

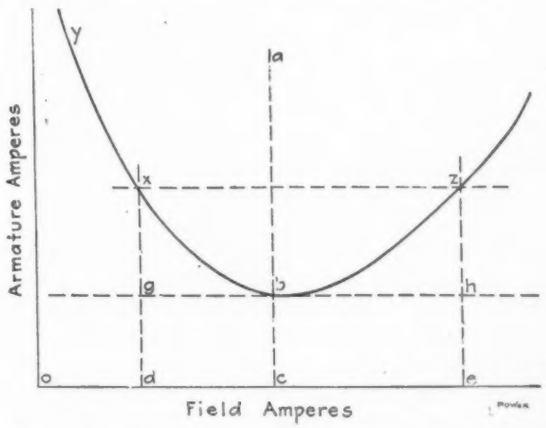


FIG. 5. SYNCHRONOUS MOTOR CHARACTERISTICS

open-circuit run, letting the voltage come what it will. Call this voltage V_1 and the normal voltage V. Then the calculated percentage regulation, R equals $\left(\frac{V_1 - V}{V}\right)$. Continuing such an open-circuit run until the temperatures are constant will give a very fair idea of the field temperatures that may be expected at full load.

Immediately following the open-circuit run, a short-circuit run should be started, at a considerable percentage above the rated current. This is a test on the armature, pure and simple, as the field excitation will be low.

EFFICIENCY FROM LOSSES

Should the purchaser wish to satisfy himself regarding the guarantees for efficiency, the procedure would be to measure the losses directly and compute the efficiency from them. The losses of an alternator may be classified as follows: Copper loss, iron loss, friction and windage. There are two subdivisions of copper loss, namely, field and armature loss. The field loss is determined by measuring the resistance of the field very carefully while hot. The loss in watts is then computed by substituting in the familiar expression, $W = I^2 R$. As to the armature loss,

the same expression can be used, as the reactance of the armature does not cause any heating.

The iron or core loss is composed of hysteresis and eddy-current losses. Its collective magnitude, including friction and windage, is determined by means of belting a small direct-current motor to the alternator and measuring the motor input in watts necessary to run the combination at various alternator excitations and later subtracting the power necessary to run the motor alone.

The belt used should be as light as possible and not laced but should be endless, because any irregularity will make the motor-input ammeter needle jump every time it passes over the pulley and thus increases the liability of error. Sometimes when all conditions are the best that can be obtained, the ammeter needle still has a very annoying swing. This has been overcome in several instances by reactance in the motor-armature circuit.

The motor field should be separately excited and the rheostats in the field circuit should be so arranged that some convenient field strength can be held constant throughout the test. This value of the field current must not be varied under any circumstances. The motor armature is to be wired to some independent source of power whose voltage can be varied at will over a considerable range. The rheostats for this purpose should be convenient to the man holding speed and the speed of the alternator must be held as close as possible to the normal value throughout the test, by varying the driving-motor voltage, the two brushes used to measure the armature voltage on the motor must be thoroughly insulated from their boxes by wrapping with paper. This will eliminate the drop due to brush and brush-holder resistances.

The motor and alternator should first be run at approximately normal speed for an hour or two until conditions become steady; then take readings for the core-loss curve. These are taken with the alternator open-circuited and are carried up to 25 per cent. above normal voltage. The field current for each point must be rising; that is, do not go above a certain value and then drop back to it again. If the field current rises above that intended, take the reading at the higher point. Take several readings close to normal excitation and one point exactly at normal. Readings may be conveniently tabulated according to the following form. After ten or twelve points have

Generator				Motor				
VA	VF	AF	Speed	VA	VF	AA	AF	Speed

been taken, plot a trial curve between motor-armature amperes and alternator excitation to see if any points are radically wrong and if they are, check them. There should be no sudden change in the motor voltages from one reading to the next. Now, without any excitation on the alternator, take a very careful reading on the motor. Next, remove the brushes from the alternator rings and take another reading if desired. This is to separate the brush friction, which may be so small that it cannot be read.

The belt is next removed and the power necessary to run the motor alone is determined. Hold the same field strength that was held throughout the core-loss curve; also hold normal speed by adjusting the voltage. After this the motor should be shut down and the armature carefully measured to determine the $I^2 R$ loss of the motor armature. Tabulate the alternator-field excitations and the corresponding motor-watts input, and plot the curve which has the general shape *ab*, Fig. 6. The motor watts at no alternator-field excitation are the friction, windage and brush losses of the alternator, including motor losses and are constant for all field strengths of the alternator except for the increment of additional $I^2 R$ loss over and above the runing light $I^2 R$ loss of the motor occasioned by increased armature current. These losses, excepting the variable additional $I^2 R$ loss of the motor, are represented by *cd*, *cg* representing the variable $I^2 R$ and *ef* the wattage input to the motor with the belt thrown off. Assume that the point *z* on the curve *ab* is at normal excitation. Then *wx* represents the "running light" motor losses, which are the same at every point; *xy* is the friction and windage of the alternator in watts, *yy'* is the additional $I^2 R$ loss of the motor, caused by the armature current in excess of that while running free and *y'z* is the core loss at that point. The proper core loss to use in calculating full-load efficiency, is that corresponding to the normal voltage plus the $I^2 R$ drop of the armature.

In addition to the core loss as determined, there is a second factor known as "load iron losses" and these are

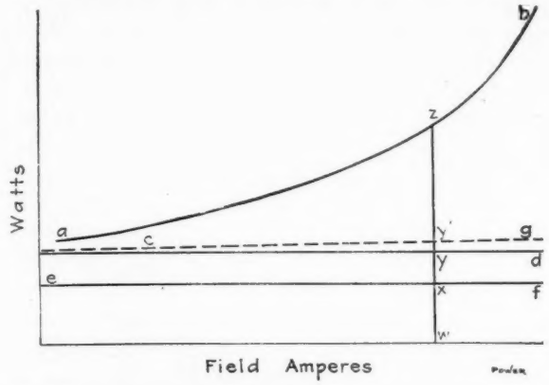


FIG. 6. VARIATION OF GENERATOR FIELD WITH MOTOR INPUT

not any too well understood. They are determined by taking readings for a core-loss curve as outlined, but with the armature short-circuited. This value, for full-load conditions, equals the core loss thus determined (with rated full-load current flowing in the armature), minus the $I^2 R$ of the armature, the remainder being divided by 3; that is $(W - I^2R) \div 3$.

Representing the total losses of full load by L, the efficiency is $E = W \div (W - L)$ where W is the watts output.

This completes the running tests usually called for on alternating-current generators.

INSULATION TEST

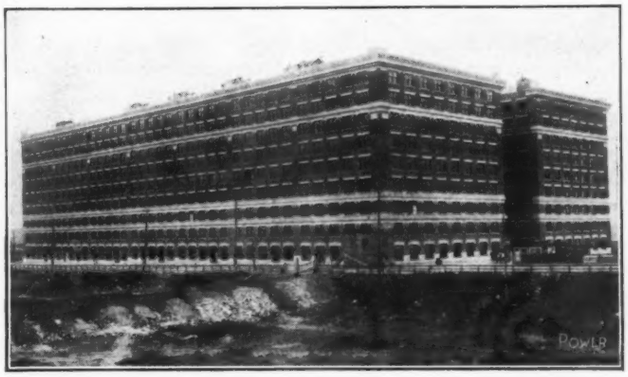
There remains the high potential test on the insulation. This should be made while the insulation is warm, because in this condition its dielectric strength is likely to be somewhat less than when cold. In every case the voltage is applied between the windings and the iron, and is left on for a period of one minute. For high-voltage machines the amount of test potential put on the armature windings is usually about double the normal terminal voltage, but on the lower voltage machines this amount is usually increased. Revolving fields all take 2300 volts or thereabouts, applied between the windings and the core.

GAS POWER DEPARTMENT

Gas Power Plant in Wool Warehouses

By E. F. Learned

The gas power plant herein described serves two wool warehouses located at South Boston, one of which is the largest in the United States. The buildings are of brick and concrete, the larger 478 ft. long, 122 ft. wide and nine stories in height. In the rear and at one end of



Warehouses in Which Plant is Installed

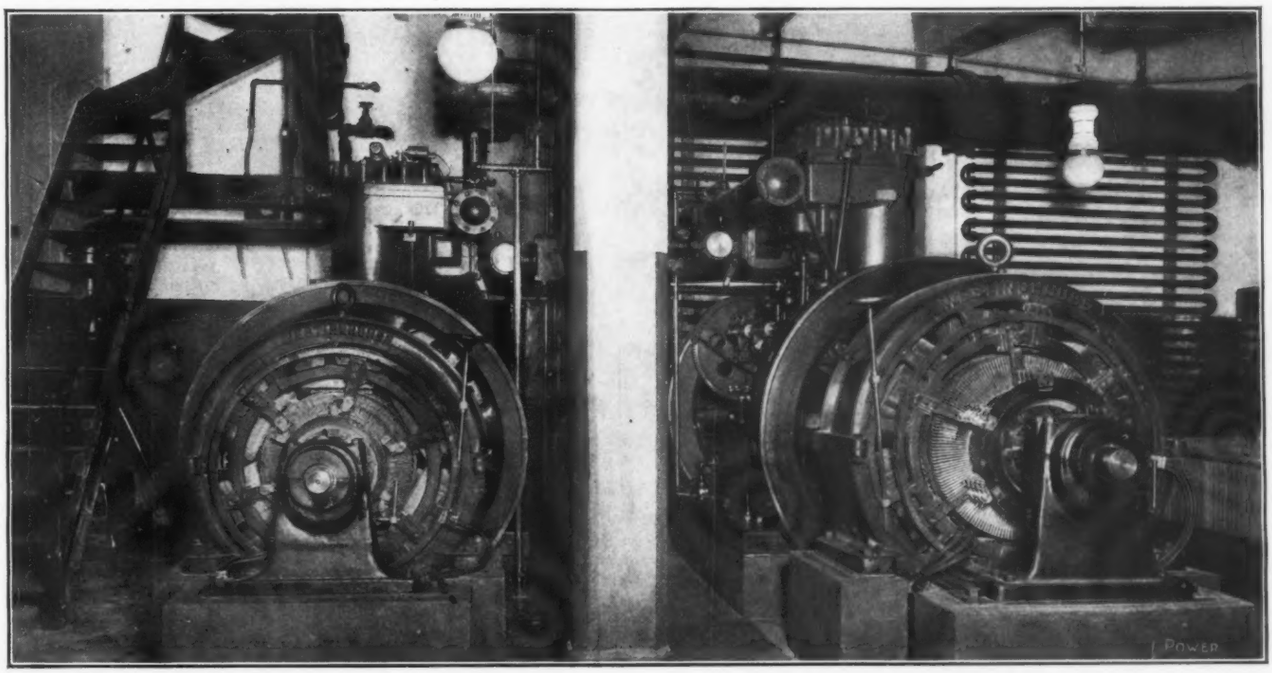
the structure, but separated from it by a narrow street, is another building about 138x107 ft., and of the same height. The total floor area of the two buildings is about 16½ acres, and the storage capacity is 10,000,000 lb. of wool. The power plant is underneath the street between the buildings and supplies electricity for the lighting and the power load.

The buildings are equipped with six passenger elevators of 1500 lb. capacity running at a speed of 100 ft. per min., nine freight elevators of 5000 lb. capacity operating at 100 ft. per min. and nine whip hoists lifting a maximum load of 400 lb. at 500 ft. per min. These machines are electrically driven.

There are two main units consisting of Nash gas engines, direct connected to Westinghouse 230-volt, direct-current generators running at 250 r.p.m. One is a 150-hp., 13x16-in., three-cylinder engine driving a 90-kw. dynamo, and the other a 100-hp., 11x14-in. three-cylinder engine driving a 62½-kw. machine. The generators deliver current to a three-wire system, all the motors being supplied from the 230-volt circuits. A rotary balancer is installed on the lighting system.

The fuel is illuminating gas, supplied by the Boston Consolidated Gas Co., a 5-in. line being carried from the service connection to two 500-light meters, with connections so arranged that the gas can flow either through both meters or one can be used as a spare. The engines are supplied through 4- and 3-in. branches from a 6-in. line leading from the meters. A bypassed regulator is provided in each branch.

Six vertical air tanks, working under 180 lb. pressure and supplied by a 6x6-in. motor-driven Curtis compressor, are provided for starting the engines. Cooling water for the compressor is supplied through a ½-in. pipe from the city service. The tanks discharge into a 1¼-in. line serving each engine. An auxiliary com-

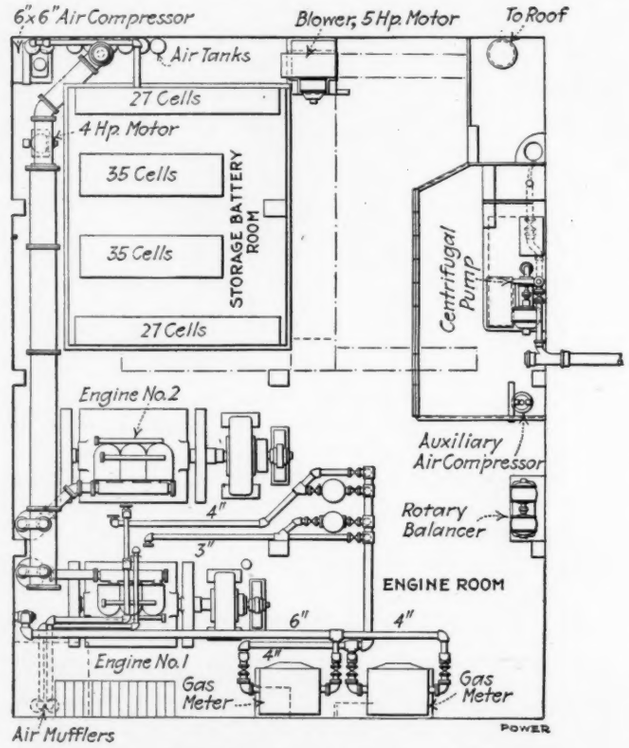


General View of Engine Room

pressor, belt driven by an 18-in. Pelton wheel, is installed with a 1-in. pipe connecting to the 1¼-in. air line. This wheel is supplied under about 48 lb. pressure by a 2½-in. pipe from the service connection and discharges into the sewer.

The exhaust pipes from the engines are 6 and 5 in., respectively, and lead to mufflers discharging into an 18-in. manifold about 26½ ft. long. A 12-in. pipe connects the manifold with a 12-in. wrought-iron riser extending 6 ft. above the roof. The pipe and riser are drained by a 1-in. pipe leading to a 2½-in. drip line from the mufflers.

Cooling water for the engines is supplied through 1½- and 1¼-in. branches from the city water supply. The heated jacket water may be used in heating the plant by passing it through two 2-in. return-bend wall coils, each



Plan of Engine and Battery Rooms

containing about 350 sq.ft. of radiating surface, or it may flow through connections to a 2½-in. line and siphon into the sewer. The siphon is fitted with a check valve and an overflow pipe leading to a sink. Low-pressure boilers are also installed, however, for heating the offices.

Provision for engine ignition is made by 20 cells of type "ET" chloride accumulators and a 2-hp. motor-generator set. The capacity of the storage battery is 20 amp.-hr. at 40 volts. Current from the battery is used in starting the engines, and after the generators are in operation the motor-generator is switched into service, either supplying the batteries or furnishing the ignition current.

A third system of electric ignition is provided by the use of an independent source of electricity consisting of 24 cells of dry battery with leads carried in a separate conduit to the engines.

There are also 124 cells of type "E 11" chloride accumulators having a rated capacity of 25 amp. for 8 hr. During the day the battery is used to regulate load fluctuations through a range of about 125 amp. At night it supplies the lighting and elevator service after the generators are shut down. The battery jars are of such size that the rating of the battery can be increased 50 per cent. by the installation of additional plates.

The main circuit-breakers are equipped with reverse-current relays to insure against trouble caused by an engine working badly when the generators are connected in parallel, or from the battery feeding back to the machines.

The power load consists of six 10-hp. motors, nine 20-hp. motors, and nine 11.5-hp. motors operating respectively the passenger and freight elevators, and the whips. The lighting load consists of 2805 sixteen-candlepower equivalents. Only one generator is operated at a time, the other being held in reserve.

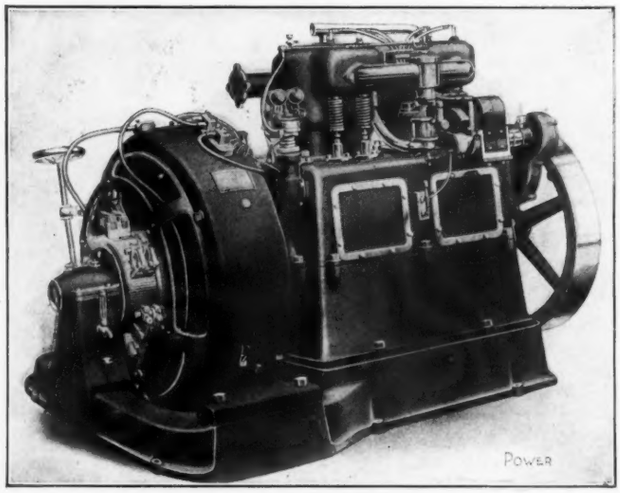
The plant is ventilated by natural and forced-draft systems. Two brick vent stacks about 5x5 ft. in section are located at opposite corners on the same side of the engine room, extending from the ceiling to a height of approximately 10 ft. above the level of the street. Swinging sashes are provided at the tops of the stacks permitting the draft to be regulated at will. In the forced system of ventilation the air is withdrawn from the upper portion of the engine and battery rooms through ducts and is exhausted by a 50-in. motor-driven blower which exhausts into a duct leading to a 20-in. galvanized-iron duct carried to the roof. There are openings about one foot square near the floor in each side of the battery room permitting a circulation of air to be maintained.

The engine room is lighted by gas, arc and incandescent lamps.

The installation was designed by W. H. Edmondson, engineer of the Boston Consolidated Gas Co.

Gasoline-Electric Generating Set

A line of small gasoline-electric generating sets, intended primarily for such service as country estates, shops, vessels, etc., has recently been put out by the B. F. Sturtevant Co., of Hyde Park, Mass. At present three sizes are



10-Kw. Gasoline-Electric Generating Set

built, namely, 5, 10 and 15 kw., the engine being mounted on the same base as the direct-current generator.

The engines are of the four-stroke-cycle, vertical, multi-

cylinder, long-stroke type with four or six cylinders, according to the capacity. In the 5-kw. set the cylinders are cast "en bloc" with inclosed valves and integral inlet and exhaust manifolds; in the larger sizes the cylinders are cast in pairs as in the illustration.

Forced lubrication is employed, oil being supplied under 20 lb. pressure to all the bearings by a gear-driven pump. The lower part of the base forms an oil reservoir holding sufficient oil for 50 hrs.' use.

Regulation is effected through a centrifugal governor, driven by bevel gears from the camshaft and controlling a throttle valve.

To Investigate Substitutes for Gasoline

Announcement is made of the active coöperation of the National Association of Automobile Manufacturers and the Society of Automobile Engineers in a movement to investigate the applicability of kerosene and other low-grade petroleum products as a substitute for gasoline. This movement is significant in that it is the first definite response to the present complaints throughout the country against the advance in price of gasoline accompanied by a lower-grade product.

Although only tentative plans have been made thus far, the commercial side of the problem will be handled by the manufacturers' association and the research work will be looked after by the automobile engineers.

Special opportunity will be given inventors and others who are interested in the development of new fuels as substitutes for gasoline to demonstrate not only their applicability to automobile propulsion, but also the extent to which they can be produced and the probable relative cost. In this connection the investigation will study fuels, such as the new motor spirits, recently placed on the market by the Standard Oil Co., of Indiana, which is manufactured from a residue formerly marketed at a low price as fuel oil.

Coal tar, peat and even vegetable refuse are possible sources of hydrocarbon compounds that may be used as fuel that are at present under investigation by various authorities, while several companies have recently undertaken the exploitation of fuels declared to be suitable as gasoline substitutes which are not directly dependent on the petroleum market, or which are entirely independent of it. Those interested in substitute products, as well as in new processes for increasing the yield of gasoline and similar products from petroleum itself will be invited to place them before the investigators.

In a similar way, inventors of carburetors and other devices calculated to adapt the ordinary gasoline engine to the use of kerosene, distillate and similar low-grade fuels, will be given opportunity to demonstrate their merits to the satisfaction of the investigators. An important aspect of the work will be a study of the carburetion methods at present employed with a view to determining what modifications are necessary in order to cope with the low-grade gasoline that is available at present, and pending possible relief, from whatever source it may be derived.

Considering the convenience that it affords and the price of retail current from central stations, electricity from a gasoline-electric plant can be produced at a cost that will stand very favorable comparison with the cost of a similar supply from any other source.—"The Isolated Plant."

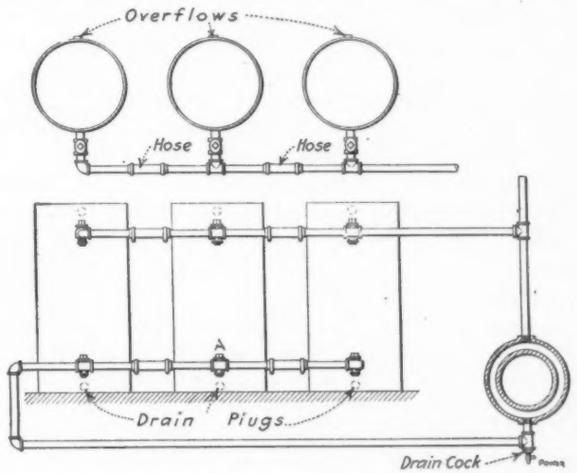
CORRESPONDENCE

Circulating Systems

In an article on "Gas Engine Jacket Circulating Systems," by A. C. Wilson, in the Mar. 4 issue, methods are given for connecting circulating tanks. There are several objections, however, to the use of tanks connected, according to the methods shown.

One very serious objection is that it would be impossible to cut out one tank in case of a leak, or other necessity, without cutting off the water from the engine altogether. Also in Figs. 3 and 4, the hot water coming from the engine jacket must descend to the bottom of the first tank, then rise to the top and enter the second tank, then descend to the bottom and so on. In my opinion this would result in poor circulation.

The sketch herewith submitted shows the method used by one of the largest builders of gas engines in the United



SUGGESTED ARRANGEMENT OF TANKS

States. By this arrangement any tank in the series may be cut out without affecting the circulation of the water through the remaining tanks. This is very convenient, for, in case a tank should spring a leak, it can be shut off from the line, drained and repaired. Also, in cold weather when it is not always necessary to use all the tanks one or more may be cut out to keep the water at the proper temperature. This is very important on hoisting engines where the load is intermittent and the engine operates a part of the time without a load.

In engines above 32 hp., a circulating pump is placed in the lower pipe line.

C. C. DWIGHT.

Salt Lake City, Utah.

If you work for a man, in Heaven's name work for him. If he pays you wages that supply your bread and butter, work for him; speak well of him; stand by him and stand by the institution he represents. If put to a pinch, an ounce of loyalty is worth a pound of cleverness. If you must vilify, condemn and eternally disparage, why, resign your position and, if you are a weakling, when you are outside damn to your heart's content. But as long as you are a part of the institution, do not condemn it.—"Pacific Service Magazine."

REFRIGERATION DEPARTMENT

Refrigeration with Carbon Dioxide

In previous articles in this department the use of ammonia for refrigeration by means of the compression and absorption systems was described. There are other mediums which have been used with varying degrees of success. Air, sulphuric ether, sulphur dioxide and carbon dioxide may be mentioned as examples, and of these carbon dioxide now has much wider use than any of the others. It is commonly called carbonic-acid gas and its chemical symbol is CO_2, which means one part of carbon to two parts of oxygen by volume. As a gas it is present in the air in volumes varying from 2.7 to 3.5 in 1000. It is the substance used in soda fountains and causes the effervescence in wines and beers. Commercially it is produced from coke, magnesite and other substances, or may be collected from the fermenting tubs in breweries. With the proper apparatus it may be obtained from the air or even from the flue gases of a boiler. It is comparatively cheap and due to its neutral action toward materials and food products it is largely used for the refrigeration of storage rooms in hotels and restaurants. It is also preferred at sea, as leakage of ammonia vapor into the limited volume of a vessel might readily produce disagreeable and perhaps fatal results. Air containing up to 8 per cent. of carbonic-acid gas may be inhaled without danger, whereas ½ per cent. of ammonia may prove fatal. The gas is without color and odorless, and the presence of a leak may not be easily detected, unless peppermint or some other substance with a strong odor is injected in the refrigerating system. It is heavier than air, its specific gravity being 1.529, so that it will tend to drop to the floor of the engine room and may not reach the breathing line.

Under atmospheric pressure carbon dioxide will boil at a temperature of 124 deg. F. below zero. At a temperature of 96 deg. it requires a pressure of nearly 1100 lb. to liquify it, at 30 deg. a pressure of approximately 500 lb. and at zero a pressure close to 300 lb. Its latent heat at zero temperature is 123 B.t.u. as compared to 570 for ammonia. In other words, one pound of the liquid at the given temperature, in changing into a gas in the expansion coils, will take up only 123 heat units from the surrounding room or brine. For the same volume, however, at a temperature of zero, carbon dioxide is about 32 times heavier than ammonia, so that a compressor to give the same refrigerating effect need be only one-seventh as large. In ordinary practice the ratio is usually placed at 1 to 6. The working pressure ranges from 50 to 70 atmospheres (750 to 1050 lb.), but the bore in machines of moderate capacity is so small that there is no difficulty in obtaining a cylinder and fittings to withstand the pressure.

As the operation is identical with that of the ammonia-compression system there will be no need of an illustration. Reference may be made to the previous drawing, which shows a compressor, condenser, expansion valve and expansion coils. These are the essential parts of a compression system using carbon dioxide. The drawing indicates an atmospheric condenser and shows the expansion coils located in a brine tank. In modernly equipped plants double-pipe counter-current condensers are usually installed and also double-pipe brine coolers. The direct-expansion system, in which the coils are located directly in the room to be cooled, may be used with equal facility unless the storage of a cold supply of brine to carry the plant over periods of nonoperation is desired.

For average operating conditions carbon dioxide gives results almost as efficient as ammonia. As the temperature of the cooling water increases, its efficiency falls off rapidly, and with water near 90 deg. is considerably lower than for ammonia with the same temperature of water.

Winter Work in a Refrigerating Plant

By Fred Ophüls

In the Mar. 25 issue of Power, an article* appeared under the same heading in which some of the various causes which give rise to the decrease in the ice output of a simple can ice-making plant are given. It is interesting to give some actual figures which can be obtained from the engineer's log therein referred to.

Ammonia Compressor

A great deal has been said about the proper way to operate an ammonia compressor to develop its greatest pumping capacity. The engineer had heard that some of the ice-machine manufacturers advocated operating their ammonia compressors with wet ammonia vapor. The quality of the vapor entering the compressor can be approximately determined by the discharge temperature. That is to say, when the compressor is operating with a 15-lb. suction pressure and a 185-lb. condenser pressure, saturated vapor, carrying no liquor with it, would leave a compressor, with some little clearance, at a temperature of about 250 deg. F. If moisture is present the discharge temperature is decreased and can be decreased until the boiling point of the liquid ammonia at the discharge pressure is nearly reached. The wet-gas compressors are generally operated with a discharge temperature of from 150 to 180 deg. F., for the range of pressures above given.

The engineer thought it wise to investigate this claim for himself and operated his ice-making system for a week so that the discharge temperature was maintained at between 150 and 180 deg. F. To his great astonishment he found that there was a marked reduction in the output of the plant when the machine was operating at the speed which he had previously found to give the best

*In this article an error crept into a sentence at about the middle of the third paragraph of the first column on page 422. The sentence should read: "While it has been often suggested to collect these gases in a separate receiver located over the condenser and connected with it, this method is not as effective as blowing off each condenser stand separately when practically all the ammonia has been pumped back into the condenser and receiver." The four words, "the other stands of," should have been omitted as they imply a different method of procedure.

results. The ice output showed a decrease of fully 20 per cent. This enormous decrease was found to have been caused solely by a decrease in the pumping capacity of the ammonia compressor due to carrying over or injecting liquid ammonia into the compressor.

A well designed ammonia compressor in good condition will draw from the suction pipe 75 cu.ft. of saturated ammonia vapor for every 100 cu.ft. of piston displacement. The injection of liquid ammonia into the compressor had reduced the amount of ammonia vapor pumped from 75 to 60 cu.ft. per 100 cu.ft. of piston displacement.

While theoretically it can be proved that the presence of liquid ammonia in an atomized form throughout the vapor during the suction period should result in an increase of the pumping capacity, results of actual tests have shown that this condition of operation cannot be reproduced and that liquid ammonia if carried over from the ice-making side of the plant or injected at the compressor enters the latter in bulk and lodges against the internal heated surfaces of the compressor, causing an undue reëxpansion on the return stroke of the piston on account of the rapid transmission of heat to the liquid from the metal surfaces.

For compressors with small clearance it is sometimes necessary to carry the discharge temperature as high as from 275 to 290 deg. F. for the pressure range above given. The operating engineer can readily determine at what discharge temperature his ammonia compressor will operate most efficiently if he takes the necessary trouble to maintain conditions nearly constant for a week and by varying the discharge temperature each week at least 25 deg. F.

It is difficult to give in figures the reduction in pumping capacity of an ammonia compressor on account of the leakage of the valves, valve-cage joints and pistons. For very large leakage, such as may be caused by the sticking of valves, the pumping capacity can be reduced to nothing and the only way to control this cause of loss in output is to make the provisions at the compressor suggested in the former article.

Lubricating Oil

The importance of having proper lubricating oil for the ammonia compressor is often overlooked. Very few oils are really suitable for this part of the machinery and often, on account of cheapness of price, an oil is bought which will cost the purchaser in loss of capacity, many hundred times as much as he saved on the oil. If it is taken into consideration that for a discharge temperature of, say, 250 deg. F., and a volumetric efficiency of 75 per cent. the actual temperature of the vapor at the end of compression may be as high as 380 deg. F., it will be appreciated that the quality of the oil plays an important part in the operation of the compressor.

The suction gas entering the compressor can have a temperature as low as zero for a suction pressure of 15 lb. gage, so that it is desirable to use an oil which has a congealing point below zero and a flash point higher than 380 deg. F. Such an oil is difficult if not impossible to obtain and if any compromise has to be made in these qualities it will be better to sacrifice the congealing point rather than the flash point where the oil is used for lubricating the compressor only.

When a low flash point oil is used, the action of the heat of compression on the thin film of oil covering the internal compressor surfaces will cause some of the oil to vaporize. Part of the vaporized oil is discharged into the condenser, another part remains in the clearance of the compressor. The percentage of oil vapor in the clearance at the end of the compression stroke is probably greater than is generally believed and as soon as the piston starts on the return stroke this vapor will give up its latent heat again in condensing and, therefore, maintain a high temperature until the suction valves open. In this way the percentage of reëxpansion is increased and the amount of vapor that can be drawn into the compressor decreased. That some of the lubricating oil actually vaporizes in most ammonia-compression systems is beyond doubt, as anyone knows who has had occasion to operate and study this type of machinery.

In air-compressor practice proper lubrication has been found to be a serious question, as lubricating oils of too low a flash point have often been the cause of explosions, an explosive mixture being formed by the oil vapor and the air. For this reason it has also been found dangerous to compress air with ammonia compressors that have been in service for some time. In these machines all the internal surfaces of the compressor and its piping are coated with a thin layer of a low flash-point oil. When air is compressed from atmospheric pressure to about 200 lb. gage for testing ammonia coils a temperature is reached in and near the compressor which is higher than the flash point of the oil and explosions have resulted from this cause. Ammonia compressors should never be used for compressing air unless they and their pipe connections have been thoroughly cleaned and coated with fresh oil of a sufficiently high flash point.

Ammonia Condenser

The amount of steam required to operate a refrigerating system not only varies with the suction pressure but also with the condenser pressure. The higher the former and the lower the latter the less steam will be required. In such plants where there is more than sufficient cooling and condensing water available the question comes up as to what quantity of water showered over the ammonia condensers will give the least total steam consumption of the refrigerating machine and the water pump. The minimum point can be found both by experiment and calculation. In the former case it is only necessary to operate the plant with varying quantities of water showered over the ammonia condenser and by plotting the results so obtained the minimum steam consumption can be determined. The calculation of this problem requires a knowledge of the horsepower necessary to operate the refrigerating machine under varying suction and condensing pressures, the steam consumption of its engine per horsepower-hour, the variation in the condenser pressure and liquid ammonia temperatures with the quantity of water used, the initial temperature of the condensing water, the total head against which the water must be pumped, the steam consumption of the water pump, and its mechanical and volumetric efficiencies. On account of the great variation in the initial temperature of the condensing water, the initial steam pressure and the type of the engine operating the refrigerating machine, these calculations must be made for each individual installation.

For the plant from which these data were taken it was

found that with 70 deg. F. water showered over the ammonia condenser using a duplex, direct-acting steam pump working against a total head of 150 ft., the minimum combined steam consumption of the refrigerating machine and water pump was obtained when 1.7 gal. of water per minute were showered over the ammonia condenser per actual ton of refrigeration produced. The refrigerating machine was operated by a Corliss steam engine using about 28 lb. of steam per indicated horsepower-hour.

The log data also showed that the temperature of the liquid ammonia leaving the condenser was from 10 to 15 deg. higher than the initial temperature of the condensing water used. By installing a separate liquid cooler this difference was reduced to 5 deg. with a corresponding saving in the steam consumption of the refrigerating machine of about 2½ per cent.

Distilled Water

There are a great many ice-making plants in operation today in which the distilled water enters the ice-making cans at 70 deg. F. and higher. If one remembers that this water must first be cooled to 32 deg. F. before it will freeze and that due to its construction a simple can ice-making system does not remove heat efficiently, it will be appreciated that not only an increase in capacity but also a decrease in the operating expenses can be secured by reducing the temperature of the distilled water to about 32 deg. F. before it enters the ice cans. For example, it was found that by reducing the distilled water from 70 to 35 deg. F. in a separate distilled water cooler of proper construction, the capacity of the freezing tanks was increased 15 per cent. This does not mean that with the same ammonia compressor 15 per cent. more ice could be made, but that if an additional compressor is installed or else the existing compressor could be speeded up sufficiently the freezing tank would give 15 per cent. more ice without an expenditure of one cent in its equipment.

Freezing Tank

About 48 hr. are required to freeze a 300-lb. block of ice of standard dimensions. In the plant under consideration it was found that in certain parts of the tank the cans froze more rapidly than in others. On closer investigation it was determined to improve the circulation of the brine and also raise its level in the tank about 1 in. The result was a gain of 2 hr. in the time of freezing, which meant an increase in the ice output of the tank of 5 per cent., and a decrease in the total cost of manufacturing the ice of about 5c. per ton solely on account of the increase in capacity for the same initial investment. This meant for a 100-ton ice-making plant making 24,000 tons of ice per year, a saving of $1200.

The effect of the improper handling of the expansion valves is difficult to express in terms of per cent. of output as this cause of loss in capacity varies enormously. It has been proved that by installing the flooded or gravity-feed system the capacity of the plant in some cases can be increased 10 per cent.; everything else, such as the speed of the machine, condenser-water pump, etc., remaining the same. This figure also represents the saving that could have been effected by a proper manipulation of the expansion valves of the simple system provided the brine-cooling coils had been properly proportioned for the work.

Compressor Diagrams

It is very seldom that I see any indicator diagrams from ammonia compressors in Power. Having had occasion to take some diagrams, I thought that they might interest other engineers.

Figs. 1 and 2 were taken from a Ball compressor equipped with the old-style suction and discharge valves, which are not as efficient as the newer style of valves placed in the heads of the compressor. This machine has a refrigerating capacity of 125 tons, and is driven by a tandem-compound Corliss engine cross-connected. The compressor diagrams were taken at different suction and discharge pressures and at different speeds, 58 and 48 r.p.m. The cylinder was 21x48 in., and the piston rod 4¼ in. in diameter. Following is the data relating to the diagrams:

	Card No. 1	Card No. 2
Head pressure, lb	155	135
Suction pressure, lb	18	25
R.p.m.	58	48
Spring	120	120

Figs. 3 and 4 were taken from the high- and low-pressure cylinders of the engine. The operating data are tabulated below.

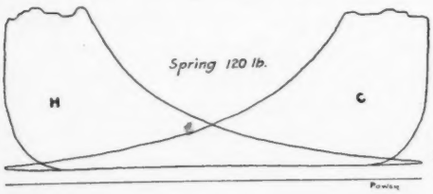


Fig. 1. Compressor Diagrams, Speed 58 R.P.M.

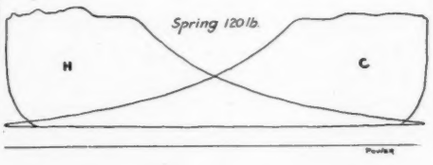


Fig. 2. Compressor Diagrams, Speed 48 R.P.M.

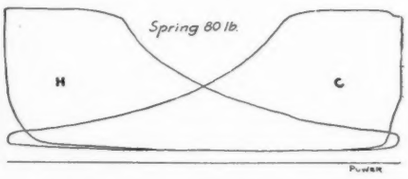


Fig. 3. Diagrams from High-Pressure Cylinder of Engine

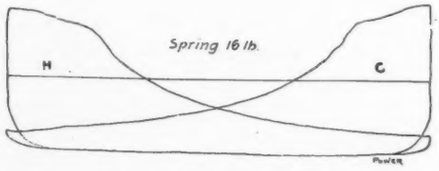


Fig. 4. Low-Pressure Cylinder Diagrams

Steam pressure, lb	125
Receiver pressure, lb	11
Vacuum, in	24
R.p.m.	58 and 48
Diameter low-pressure cylinder, in	38
Diameter high-pressure cylinder, in	18
Diameter of rod, in	4¼
Stroke, in	48

C. E. Anderson

Chicago, Ill.

EDITORIALS

The Coming Engineer

Do you realize what 15,000 kilowatts mean?

With an overall efficiency of ninety per cent. it means nearly 23,000 indicated horsepower.

On a recent visit to the Westinghouse shops at East Pittsburgh, we found seventeen units of this capacity under order. There were also units of 20,000 and 22,500 kilowatts and numerous smaller units in the shop.

What does this mean?

It means that there are upward of 500,000 indicated horsepower of reciprocating engines which are not going to be built nor run.

It means that there is the equivalent of upward of 500,000 indicated horsepower of old-fashioned stationary engineers who are not going to be required to run them.

There are going to be fewer engineers, but they are going to be bigger, better engineers. The little slip-shod plant and the engineer who is not much more than a janitor is going to be displaced by these big efficient units in central stations. The man who will hold his job will be the man who can run his plant cheaper than the central station can sell the service, and who is able to show his employer that he can do so, against the most aggressive and efficient selling organization that this age of progress has produced.

Don't be old-fashioned; don't be stationary. Qualify yourselves to take care of one of these big stations or at least to so run a smaller one that the big one cannot wipe it out.

⁂

The Manufacturers' Opportunity

Professors preponderate as authors of papers presented before engineering and similar societies and comparatively few are contributed by heads of manufacturing firms. Attention was called to these facts by Prof. A. K. Huntington in his presidential address to the Institute of Metals.

Due to their special experience, often gained by hard toil and years of experiment, manufacturers should be able to give out a wealth of valuable information, and yet from a membership of manufacturers, users and scientific men in the relative proportions of thirty-seven, thirty-four and twenty-nine per cent., the percentage of papers presented was nine, fifteen and seventy-five. In the technical press, the same proportions would not hold, but the user and scientific man have a long lead over the manufacturer.

One has not far to go to discover the reason for this disparity. As a rule, the manufacturer has little inclination to write. His time is fully occupied, and even if he had the time and disposition, he is adverse to giving away so called trade secrets, more particularly if the information is such that the patent office offers no protection. These at least are the doctrines of the old school. The uptodate manufacturer is beginning to realize that there is nothing gained by secrecy. What he has learned as a specialist and what he is doing are of interest to the other fellow and the information from others in the same line is of value to him. The publication of this material with the ensuing discussion would add materially to the general store of knowledge.

Hiding one's light under a bushel never resulted in any lasting benefit to those concerned. It is a narrow policy which, if observed by all, hinders development and curtails business possibilities. To be recognized as the leading authority in the country on a particular subject is worth something to the manufacturer, and to turn over to the user his information on the subject is worth more. A mysterious machine or device, whose operation and construction are not thoroughly understood, is not the machine that will sell and continue to be a steady source of income to the firm. It is the machine that everybody knows, the machine that any user can operate and one whose efficiency lives up to its reputation, which will be in constant demand.

A thorough knowledge on the part of the user bespeaks confidence and the individual imparting this information in a form understandable to the average reader, incidentally helps himself. He classifies his own ideas, crystallizes them into more definite form and has them available at his "finger tips." The many little sidelights that he will invariably put into his work are the "fine adjustments," which bring his product to a focus and dispel the haze surrounding an unknown device.

A realization of these facts on the part of the manufacturer should result in some real information, and the more the better.

⁂

Unsymmetrical Boiler Joints

A paper read before the New South Wales Engineering Association, an abstract of which was given in a recent issue, apparently indicates that the exact shape of the joined ends of the plate has a marked effect on the maximum fiber stresses that may be produced along the joined surfaces; and especially at the point where lap cracks tend to form.

It is well known that relatively few of the total number of lap joints used in boilers actually produce explosions by cracking. It is not possible to know how many seams of this form of construction have started a crack or been on the verge of explosion at the time the boilers, on which they were located, were abandoned. However, it is safe to assume that if all were carefully examined, a large majority would be found perfectly sound. With tests of only two specimens, as given in the paper referred to, ample evidence was given of the widely varying stresses that may be expected in this form of construction by changing the form of the joined ends of the plate. Several years ago, POWER contained the explanation of a theory regarding the formation of cracks in the vicinity of boiler seams. This theory assumed that at some more or less well defined pressure the initial spring in the plate (caused by the forcible connection by rivet-

ing of mismated ends of the plate) was just overcome.

It was also assumed that when the working pressure happened to coincide with this initial pressure, a movement of the joint might be caused by very small fluctuations in the pressure; say, such as might be produced by the intermittent draft of steam to supply a reciprocating engine. If this theory is correct, it would seem to supply all the required flexibility to account for the erratic nature of the formation exhibited by the cracks in most forms of boiler joints. It would be interesting to ascertain by using fixed mirrors, as described in the paper referred to, if joints formed with mismatched plates do show a point of marked minimum resistance to deformation when the vessel, of which they form a part, is subjected to internal pressure. If so, the frequent application and release of the high surface tension which would be produced in such joints and which would likely be confined to narrow limits, would eliminate quality of material as a necessary factor in the formation of such cracks.

It is interesting that, although the claim has often been made that defective material is the true explanation of such failures, there has been practically no direct evidence that this is a fact. In two cases mentioned in the paper to which we have referred, tests of the material which cracked showed it to be of first-class quality. Any theory regarding the formation of lap-joint cracks, that may be applied equally as well to all joints of this type, is necessarily wrong, because it is well established that these cracks do not form in all lap joints; nor has it yet been shown that they always tend to form in such joints.

Engineering Accuracy

If any one thing distinguishes the engineer of experience from one whose reputation is yet to be made it is the sense of proportion in regard to accuracy which comes with practice to the man blessed with mental perspective. To know what is good enough for the purpose is to unlock the doors into many chambers of material reward and to avoid the waste of talents and energy which people with little imagination usually fritter away in useless strivings after unnecessary perfections. Engineering work and the tasks of the research laboratory are blood relations, but in the former nearly always the question of cost is the controlling factor while in the latter it is usually great precision. It is the old story of the difference between pure and applied science, and if the conditions surrounding the engineer are largely commercial in these days, there is nothing to be ashamed of in working within commercial limits of the truth. Many a man takes up practical engineering work in one field or another with little realization of the value of seasoned judgment in determining the proper limits of his striving after accurate results, and sometimes he remains miserable for years because the equipment at his command lacks the precision of his ideals.

Some tasks, like counting barrels of oil, barrows of coal used, and the reading and recording of registering meters, must be exact; there is no place for mistakes or approximations in judgment. Inexperienced men often fail to realize the great importance of doing this kind of work right, a point of view fostered, it must be admitted, by the practice many schools have of giving high credit for the selection of the proper method of solving problems, regardless of the accuracy of the computations. But in innumerable other tasks efforts to carry accuracy beyond the commercial limit defeat their own ends and often invite ridicule or criticism from those who know the real value and limitations of the methods in hand. Examples of such are stating the yearly coal consumption in ten-thousandths of a ton, using decimals in putting down the totals of millions of kilowatt-hours, measuring engine rooms for ordinary data-sheet purposes to fractions of an inch, or carrying out test data to percentages which the apparatus making the measurements could never reach with reliability. Often these may be merely the result of thoughtlessness, but even so, they tend to show that the man responsible for them has not yet become a master of his occupation.

Herein are found the great value of regular calibration of instruments yielding records of significance from the cost viewpoint and the usefulness of checking figures and conclusions submitted to superiors as bases for future action. To err may be human, but to verify voluntarily and to pitilessly check one's own figures on one's own initiative, marks the worker into a class above the ordinary run of mankind, training him for the responsibilities and rewards of the expert.

What shall we say of the engineering accuracy of a recent report to a state commission on the cost of electric-power production in a steam plant in which the quoted daily output divided by the stated total expense for labor, fuel and supplies does not check with the tabulated unit cost? The author took pains enough in this instance to list the number and daily wages of every man on the station payroll, but failed to verify the accuracy of the deductions from the data given, and so the part of the report dealing with the particular plant in question was heavily discounted. Whether an engineers owns a slide-rule or not, there is no question that proper accuracy in the great majority of cases calls for at least rough computations that check the values upon which attention is to be focussed, and in important matters the omission to do this throughout the entire task puts the reputation of the man in jeopardy.

No study can be more profitable than the limitations of accuracy of the tools with which one is provided; the man who knows what he can count upon and what he cannot determine with the facilities in hand not only is prepared to meet every demand upon his resources intelligently, but demonstrates to discerning superiors, by his very knowledge of his limitations, his fundamental reliability and practiced judgment.

In the death of Prof. Victor Dwelshauvers-Dery, of which more extended notice will be found on page 584 the American Society of Mechanical Engineers loses its fifth honorary member within two months.

The other losses, which all occurred in February, are Carl Gustaf Patrik deLaval, John Fritz, Sir William Arrol and Sir William Henry White. Professor Dwelshauvers-Dery was the first upon whom the degree of honorary membership was conferred. He was an occasional contributor to the columns of POWER, his latest writings being discussions of the Clayton method of analysis for indicator diagrams, and of the Duchesne experiments upon the physical properties of superheated steam.

READERS WITH SOMETHING TO SAY

Repair of Large Flange

In the brewery plant of S. Liebmann & Sons, Brooklyn, N. Y., the chief engineer has to look after the machinery of the power plant and in addition all mechanical apparatus in the brewery.

Recently an interesting repair was made on the flange of a large copper brew kettle, 20 ft. high and 18 ft. in diameter. Although this apparatus does not belong to the power-plant equipment, the same method might be used in the repair of any large flange, where, as in this case, it would have required a great deal of time and expense to take the apparatus apart.

Fig. 1 shows the steam blowing out between the flange faces, and Fig. 2 is a view of the same flange after the repair had been made, the crosses showing the limits of the defective part of the joint. The repair was made by taking out one bolt at a time near a leak and inserting

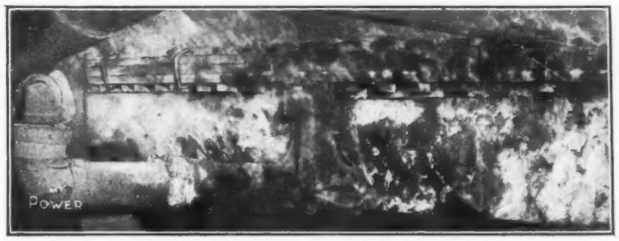


FIG. 1. VIEW OF LEAKY FLANGE

into the bolt-hole the force pump shown in Fig. 3. The outlet of the pump appears at the center of the threaded portion. The pump forced a mixture of Smooth-On No. 3 into the leak around the bolt-holes and when as much as possible had been pumped through one bolt-hole, the pump was removed, the bolt replaced and the same operation was performed at the next bolt. This was continued until all the leaks had been stopped.

While the pumping was going on, steam pressure was

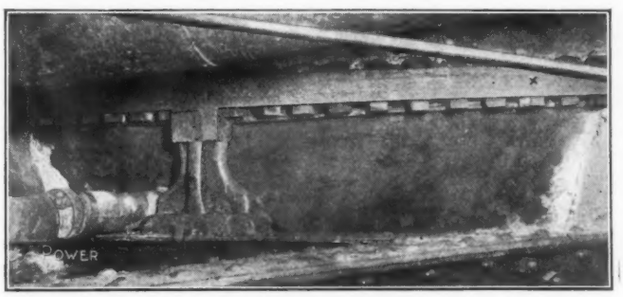


FIG. 2. AFTER REPAIR HAD BEEN MADE

maintained in the kettle so that the pump would not force the cement through the flange and in order that the heat from the steam might drive out the volatile matter and harden the cement quickly. The steam was, of course, turned off while the pump was being taken out and the bolts replaced in each case.

In a few instances, No. 1 cement was mixed with water containing a little plastic cement No. 3, and the mixture was calked into the leak from the outside. The kettle was allowed to remain out of commission for four

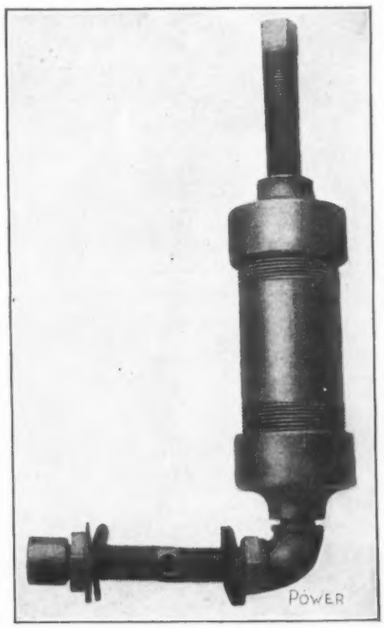


FIG. 3. PUMP USED TO INJECT CEMENT

days with a little steam turned on, and at the end of that time was put into operation. No further trouble has been experienced from leakage.

PAUL SILKE.

Brooklyn, N. Y.

Piping Mine-Pump Air Exhaust

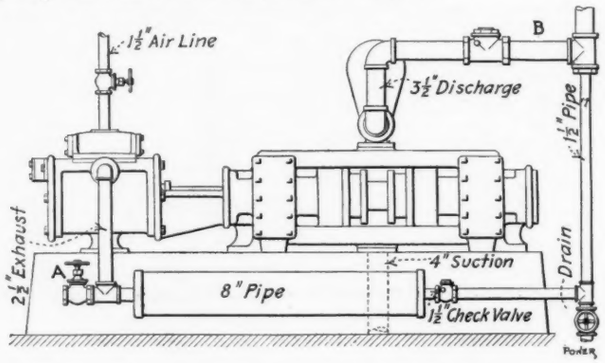
Recently, in a mine where I was employed as machinist, considerable trouble was experienced with the exhaust of a pump freezing, on the 400-ft. level, compressed air being used. The pump would run for a while and then ice would begin to form in the exhaust passages until they were choked, and a man had to keep poking the ice out with a rod to keep the pump running.

It was not practicable to reheat the air, so we resorted to other means. One of the compressor men suggested turning the exhaust into the water-discharge pipe, having seen the idea tried in several places. The 12 and 6 by 13-in. pump worked against a 400-ft. head and the air pressure carried was 90 lb.

The exhaust was piped, as shown in the illustration, to a receiver, made of a piece of 8-in. pipe, about 4 ft. long. The exhaust pipe was 2½ in. in diameter with a valve *A*, so that the pump could exhaust into the open. The outlet of the receiver was reduced to 1½ in. to cause a steady flow of air into the water-discharge pipe, and was connected to the bottom of the discharge pipe with a check

valve between to prevent water flowing back into the receiver.

When starting up, the exhaust pipe was drained and the pump allowed to exhaust into the open through the valve *A* until water was discharged through the pipe *B* from the pump. Then the valve was closed and the exhaust forced into the discharge-water pipe through the receiver and check valve, the water and air discharging to the surface. This arrangement overcame the trouble and the pump worked with no attention whatever.



PUMP EXHAUST PIPED TO THE DISCHARGE PIPE

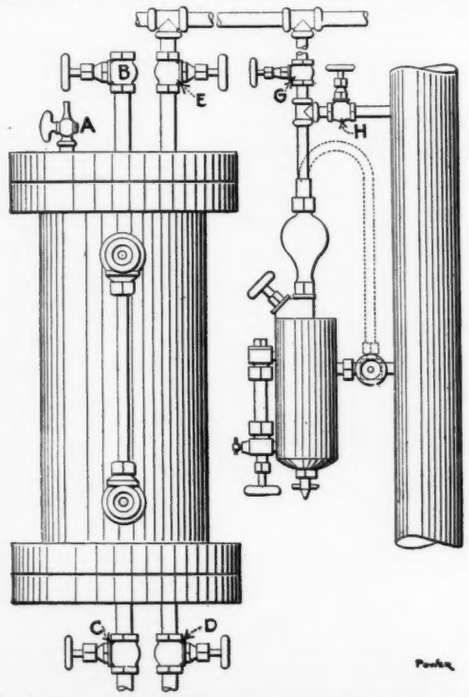
Could not this method also be applied to a pump to be worked under a greater head than that for which it was designed? For example, could a pump designed to work against a 200-ft. head not be made to work against a 400-ft. head in this way?

WALTER L. HOUSTON.

Republic, Utah.

Home-Made Central Lubricator

To save the waste of time and oil incidental to the operation of small lubricators on the auxiliaries of a steam-turbine plant, the central lubricator shown in the illustration was made and connected to the small lubricators already in service. This system, which has nine small lubricators connected to the central one, has been in use over four years and given entire satisfaction.



OIL RESERVOIR CONNECTED TO LUBRICATOR

The central lubricator is made of steam pipe, blank flanged at the ends and tapped for the connections shown. The cock *A* is used as a vent when filling the tank with oil, which is accomplished with the aid of a funnel in the valve *B*. Valve *C* is a drain or blowoff, and *D* is the steam connection. Valve *E* is the oil-main connection.

By closing valve *G* and opening *H* the small lubricator can be used independent of the central one. Where single-connection lubricators are to be connected into such a system, a steam bend is slipped out of the nut at its lower end and straightened to form, with its specially built condenser union, part of the oil line; the opening in the nut is stopped with gaskets.

To fill the central lubricator, the valve *E* is closed, then *D* and *C* are opened, then *A* and *B*. After the water has drained out, *C* is closed and the lubricator is filled through *B*. When full, *A* and *B* are closed, and then gradually the boiler pressure is applied through *D*. Finally the lubricator is put in service by opening the valve *E*.

WILFRED E. BERTRAND.

Philadelphia, Penn.

Springfield Escapes the Floods

The press reports have indicated in some instances that Springfield was wiped off the map by the recent flood, and in other cases the reports said the city was greatly damaged and the manufacturers put out of business. This is not at all the case, as none of the manufacturers here were injured by the flood, the only damage done being to a few inferior dwellings, and there was no loss of life. The statements sent out have been corrected by the press, but it is doubtful whether these small items will be read by one-tenth of the people who read the former statements. We are receiving many letters of sympathy which would indicate that the exaggerated reports were largely circulated and read, and as POWER goes directly to a large number of our customers we would be pleased to have you make known the facts in regard to this city.

We have, of course, suffered from lack of railway facilities, owing to numerous bridges being washed away, and this city has contributed thousands of dollars, and hundreds of our citizens have spent the last two weeks assisting Dayton and other sister cities. All of our factories are running, and the city is in a prosperous condition. As a matter of fact, we are advertising for more skilled labor to take care of the business the manufacturers now have on hand.

The Lagonda Manufacturing Co. and ourselves will, no doubt, be injured by the misleading reports which have been sent out, and if you can do anything to correct the impression which seems to prevail it will be highly appreciated.

JOHN J. HOPPES,
The Hoppes Mfg. Co.

Springfield, Ohio.

[As the most authoritative means of correcting the erroneous impression existing regarding Springfield, we are glad to print this letter from a responsible person at the scene.—EDITOR.]

QUESTIONS BEFORE THE HOUSE

Factor of Evaporation

In the issue of *The Journal* of the American Society of Mechanical Engineers for November, 1912, the committee on power tests submitted a preliminary report and requested the members to discuss and criticize the recommendations fully.

Among other items which the writer wishes to discuss is the factor of evaporation. Messrs. A. A. Potter and A. L. Westcott have already presented their views through the medium of POWER, and this article is intended as a reply to Mr. Westcott's discussion and in support of Mr. Potter's views. A copy of this paper has been sent to Dr. George H. Barrus, vice-chairman of the committee. Other discussions of the preliminary report will be sent to Dr. Barrus only.

One of the principal objects of a boiler test is to determine the ratio of the heat absorbed by the water to the heat supplied by the furnace.

The heat absorbed may be expressed in British thermal units, or in *equivalent evaporation,* the unit of which is 970.4 B.t.u. The heat supplied may be expressed in British thermal units or in *pounds* of a given kind of fuel.

The results will be unintelligible, or at least indefinite, until both the heat absorbed and that supplied are expressed in the same units. If expressed in different units, the relation between them must be definitely known. No confusion seems to arise when the performance of a boiler is expressed in pounds of *dry* steam per pound of coal, but it will at once appear that a result so expressed is very indefinite. The mind used to dealing with such quantities will grasp an approximate idea of the efficiency of the boiler; but nothing will be positively known, since the heat absorbed will depend upon the absolute boiler pressure and the feed-water temperature, while the heat supplied will depend upon the calorific value of the coal.

To say that the evaporation is 10 lb. of steam from and at 212 deg. F. per pound of coal is more definite, but still does not convey an exact idea. An equivalent evaporation of 10 lb. per lb. of coal whose heat value is 14,500 B.t.u. per lb. expresses the boiler performance definitely. If it were not for the fact that the trade or commercial units, *dry steam, equivalent evaporation, pound of coal* (or fuel), are so firmly rooted in the minds of most engineers, the writer would recommend that the *performance* of a boiler be expressed only as a percentage. To say that a boiler transmits to the water 75 per cent. of the heat supplied to it is a definite statement and one that is easily comprehended by even a mind not technically trained, while the statement that the *equivalent* evaporation is 10 lb. per lb. of coal is surrounded by something of a mystery to the lay mind.

Mr. Potter's ideas as to the meaning and use of the *factor of evaporation* are correct. If, as Mr. Westcott contends, the *heat of the liquid,* above the temperature of feed water, of the *unevaporated* water or moisture, should be disregarded in determining the equivalent evaporation, why should not the heat of the liquid for the evaporated water or steam also be disregarded. Does he claim that it would be economical to separate the moisture from an engine's exhaust before utilizing the steam in a low-pressure turbine? Does he not realize that 1 lb. of hot water at a pressure of 150 lb. abs., and temperature of 358.5 deg. F. will develop 36,150 ft.-lb. of work in an ideal turbine or engine operating on the Clausius cycle with a back pressure of 1 lb. abs.? He will surely agree that it would at least be economical to return the entrapped moisture to the boilers. While it is true that by disregarding 2 per cent. moisture at 150 lb. pressure an error of only about ½ per cent. will exist in final results, why neglect it at all, however small its amount, when including it will entail no additional trouble or computation?

The writer cannot recall ever having made use of the term "factor of evaporation," preferring to define *equivalent evaporation* as the amount of steam which would be formed from and at 212 deg. F. by the heat *actually* absorbed by the boiler per pound of coal fired.

Thus, if

H = Total heat of the steam, whether wet, dry or superheated;

h = Heat of the liquid corresponding to the temperature of feed;

L_a = Latent heat of evaporation for temperature of 212 deg. F.;

W = Weight of water apparently evaporated per pound of coal;

the equivalent evaporation will be

$$W_e = W\frac{H - h}{L_a}$$

The writer, therefore, recommends that paragraph (b), section 14, of the boiler code, be stricken out, and that paragraph (d) be made to read somewhat as follows:

(d) Equivalent Evaporation. The equivalent evaporation from and at 212 deg. F. is obtained from the expression,

$$W = \frac{H - h}{970.4}$$

in which

W = Apparent evaporation per pound of fuel;

H = Total heat of steam above 32 deg. F. whether wet, dry or superheated;

h = Heat of the liquid corresponding to the temperature of feedwater.

Unless otherwise provided, a combined boiler and superheater should be treated as one unit.

If it be deemed advisable to retain the term "dry steam" or "equivalent dry steam," paragraph (b), section 14, should be modified and made to read:

(b) Corrections for Moisture in or Superheat of Steam. The factor of correction, by which the apparent evaporation must be multiplied to get "equivalent dry steam" is

$$\frac{H - h}{H_s - h}$$

in which

H = Total heat of the steam, wet, dry or superheated;

H_s = Total heat of dry and saturated steam;

h = Heat of the liquid corresponding to feedwater temperature.

Finally, if the "factor of evaporation" is to remain, its definition should involve the *condition* of the steam and be expressed as follows:

The "factor of evaporation" is the ratio of the total heat of the steam, wet, dry or superheated, minus the heat of the liquid corresponding to the temperature of the feed water, to 970.4. And books containing "useful tables" should omit the table of "factors of evaporation."

JOHN S. A. JOHNSON.

Blacksburg, Va.

Collapse of a 14-Ft. Flume

The article on the "Collapse of Fourteen-foot Flume," in POWER for Mar. 18, is of much interest. The theory that the flume collapsed due to unbalanced air pressure is not entirely satisfying. The writer believes that the flume collapsed due to the weight of the water alone and did not necessarily have any help from unbalanced air pressure. A mathematical study of the forces acting in a penstock as it fills with water shows that there would be a large resultant force tending to flatten the pipe. The mathematics establishing these forces are rather complicated and have been omitted. It is sufficient to say that the resultant force would be of such magnitude as to easily cause the collapse of a flume of such large diameter. Before full pressure has been applied to a fire hose the weight of the water will cause it to assume an elliptical shape, and it is this same action which caused the collapse of the flume in question.

A filling of earth to the horizontal diameter would have tended to prevent the trouble. The earth would have supported the weight of the water and balanced the forces set up from this cause. In the case of unbalanced air pressure there would be two effects, that due to the air pressure and the one discussed above. Both act in any case, and which predominates depends on the diameter of the pipe and kind of foundation provided.

M. W. PULLEN.

Baltimore, Md.

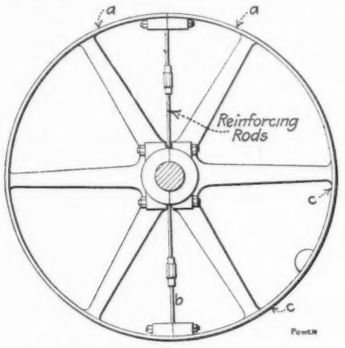
Cast-Iron Pulley Failures

The article in POWER, Dec. 10, 1912, page 848, on the results of the testing of different types of pulleys to destruction, interested me, as it confirmed my observations in actual practice.

Where I am now we have eighteen 84x12-in. cast-iron split pulleys on one shaft. They are of the standard type, held together by clamp bolts in the hub and smaller rim bolts through lugs at the rim joints, and run at a rim speed of 5937 ft. per min.

During the seven years this shaft has been in operation nine, or one-half the whole number of pulleys, have failed in the same ways mentioned in the former article. The first one to fail gave away at the rim bolts, each section containing the lugs and bolts breaking out at *a*, leaving the rest of the pulley intact on the shaft. Not long after, two others gave way in the same place, and then the rest were strengthened by reinforcing rods *b*, extending from the hub to the rim and tightened by turn buckles. The next ones to fail were those which contained the heavy balancing weights, as at *c*. By this time the rods on some of the others were loose and those pulleys began to give way at the joints again. Some would only lose one section of rim; others two sections on opposite sides, but each time either the rim joints or balance weights were responsible for the failure.

One interesting point was that in several of the failures



WHERE PULLEYS FAILED

the 10-in. double belt which ran on the pulleys was not injured or displaced, although it is difficult to see just how the section of rim could get out without tearing the belt.

We have come to the conclusion that this type of pulley is not to be relied upon at that speed, and have replaced those that gave out with pressed-steel pulleys which have proved very satisfactory.

F. P. READ.

Memphis, Tenn.

Putting in New Corliss Valve Stems

In answer to the inquiry by H. W. Lee, in the Jan. 28 issue, regarding putting new stems in his Corliss valves, if the present adjustment of the valves is satisfactory, he need only take the old stems out, place the new ones in the same position as the old ones were and mark them for the keyways.

I have put in a good many new stems and the way I go about it is this:

I remove the back bonnets, and after placing the wrist-plate on the center, fasten it there and gage the distance between the marks at the end of the valves which show the old adjustment, then take out the valves and old stems. The new stems are then put in and each valve set in the same place as before, the cranks are slipped on the new stems, everything connected up, and the keyways marked off from the keyseats in the crank hubs.

If anything has been disturbed in taking out the old stems, as, for instance, the length of the valve rods, everything must be put back in its original position before marking the new stems.

It is quite common for valve stems to become slightly twisted from use and then the valve rods may have been adjusted to compensate for the distortion. It is, therefore, better, when putting in new stems, to look the valve-gear over and see that the valve rods have not been lengthened or shortened too much, and if they have been changed they should be adjusted to their proper lengths before the keyways are marked in the new stems.

F. F. COWDEN.

New Bedford, Conn.

INQUIRIES OF GENERAL INTEREST

Effect of Decreasing Eccentric Diameter—How would the valve travel be affected if ¼ in. was turned off the eccentric?

J. H. L.

Turning ¼ in. off the eccentric would not affect the throw of the eccentric, but the eccentric rod would have to be lengthened that amount.

Humped Back-Pressure Line—If the back-pressure line on a high-pressure card from a cross-compound engine was much higher in the center, what would it mean?

A. L. M.

It would mean that the receiver was too small or the exhaust ports were not opened wide enough.

Detecting Leaking Condenser—When using sea water for condensing steam, how can it be told if the surface condenser is leaking?

W. E. W.

If silver nitrate is dropped into some water of condensation taken from the hot well, the water will turn white.

Boiler-Working Pressure—If a water-leg boiler has stay-bolts pitched 4, 5 and 8 in. apart, which pitch would be used in calculating the safe working pressure?

J. U. P.

A boiler is no stronger than its weakest part and the weakest place, as far as the staying is concerned, is where the stays are pitched 8 in. apart.

Volume of Ton of Coal—How much space does a ton of coal fill?

T. O. M.

A cubic foot of bituminous coal weighs 50 to 55 lb. Therefore, 41 to 45 cu.ft. of space is needed to stow away a ton of 2240 lb. Anthracite coal weighs 55 t 60 lb. per cu.ft., requiring 34 to 41 cu.ft. per ton f 2240 lb.

Leaks Shown by Indicator Cards—How does an indicator diagram show that the valve or piston is leaking?

G. U. Y.

The expansion line will hold up too high if the steam valves leak and if either the exhaust valve leaks, or the piston leaks, the top of the compression curve will show a downward drop just previous to admission or lead.

Added Steam Valve Lap—If more lap is added to the steam valves of a Corliss engine what else is necessary and how are the other parts affected?

C. E. D.

If lap is added on any engine the eccentric must be advanced and this will hasten closure of the exhaust valves and decrease the range of cutoff of the engine.

Compound-Engine Horsepower—How is the horsepower of a compound engine figured?

W. A. R.

Add the products of the area of the high-pressure piston by its mean effective pressure and the area of the low-pressure piston by its mean effective pressure. Multiply this sum by the piston speed in feet per minute and divide by 33,000.

Feed Pump Capacity—If you had a feed pump with 4-in. water end and desired one with twice the capacity at the same piston speed, what size would you order?

G. F. E.

The area of a 4-in. plunger is 12.56 sq.in. Twice this area is 25.12 sq.in., which is the area of a circle very closely 5⅝ in. in diameter. This would therefore be the proper size pump.

Link-Motion Engines—Some engines with link motion will run when the link is in mid gear while others will not. Why is this?

G. L. O.

Because the link is of the open-rod style which increases the lead as it is linked up from the full gear to mid gear, or in short cutoffs, consequently it will run on its lead with light load in mid gear, while with crossed rods the lead decreases as the link block is moved from full to mid gear and this type will not run the engine.

Compound Engine Ratio of Expansion—If a high-pressure cylinder with cutoff at 0.2 stroke is one-fourth as large in area as the low-pressure cylinder, what will be the total ratio of expansion in the high- and low-pressure cylinders combined?

M. A. R.

If the high-pressure cylinder cuts off at 0.2 stroke, the ratio of expansion will be 5 in that cylinder, and since the volumes of the cylinders are as 4 to 1 the total ratio of expansion for the engine will be $4 \times 5 = 20$.

Hot Studs on Circuit-Breaker—What is the cause of the studs on a circuit-breaker becoming hot and how can it be remedied?

M. W. C.

The heating may be due to poor connections causing some sparking or local heating from the high resistance. If improving the contacts does not stop the trouble the studs are probably too small for the current they carry and should be replaced with larger ones. It should not be attempted to pass more than 800 to 1200 amp. per sq.in. of cross-section of copper conductor.

A Lighting Question—A consulting designing engineer states, "The incandescent lighting system may be planned for high-voltage with 240-volt lamps requiring from 30 to 300 per cent. more current than would be required if the system was designed for 115 volts." Is he correct?

J. J. B.

It would seem as though the engineer must have been misquoted. For a given candlepower of lamps the same amount of energy will be required by lamps of either voltage, so the 240-volt lamps would take half as much current as the 115-volt lamps.

Three-Wire or Two-Wire System—What advantage, if any, has a three-wire system (motors, 250-volt, lamps, 125-volt) over a two-wire system with motors and lamps both 250-volt? Why go to the expense of the third wire?

B. J. J.

There is practically no advantage in the three-wire over the two-wire system under the conditions named. The only objections to the two-wire arrangement are in the disagreeable shock from the higher voltage and the greater fragility of the filament of a 250-volt lamp, which renders it less desirable where it is subject to vibration or much moving about.

Running with Broken Steam Valve—If the steam valve should break on a Corliss engine, how could the engine be kept running until repairs could be made?

N. O.

Turn the valve so that it will cover the port and use some means to hold it there. Then disconnect the exhaust valve of the same end of the cylinder from the wristplate and block the valve so that it will stay open. The engine will then run with one end. If it is a single-eccentric engine which cut off at $\frac{7}{8}$ stroke before, it will now cut off at $\frac{9}{16}$ or $\frac{3}{8}$ on the one end. The only difference in operation will be that the engine will not be quite so steady in speed.

Eccentricity of Eccentric—In designing a slide-valve engine with a steam port 1½ in. wide and ¾-in. lap on the valve, the valve to be driven from an eccentric, how far from the center of the eccentric should the hole be drilled f r the eccentric to give the proper throw?

P. D. A.

The travel of a slide valve is twice the lap plus twice the port opening; in this case

$$2 \times 1\tfrac{1}{2} = 3$$

and

$$2 \times \tfrac{3}{4} = 1\tfrac{1}{2}$$

the sum of these is 4½, which is the necessary throw for full p rt opening. The throw of the eccentric, which equals the travel of the valve is twice the distance from the center of the shaft to the center of the eccentric, so that if the hole is bored 2¼ in. from the center of the eccentric it will give the required 4½ travel.

ENGINEERS' STUDY COURSE

Principles of Combustion

Many believe that to understand combustion and other dark matters, such as flue-gas analysis, it is necessary to have a good knowledge of chemistry. This is not so. However, it is easiest as one goes along to have a working idea of a few simple technical terms. Therefore, when you come to paragraphs dealing with dry definitions do not shy around them but wade through. They are there for a purpose and you will be paid for your trouble in the long run.

When an engineer talks about combustion he means the burning of such fuels as wood, peat, the various grades of coal, such as lignites, bituminous coals and anthracite; coke, oil, gases and such byproduct fuels as tar, bagasse, which is sugar cane after the sugar has been extracted, spent tan bark, corn and corn cobs, etc.

The principal element in all of these fuels is carbon which, by the way, is one of the most widely distributed elements in nature. The diamond is pure carbon; sugar contains a large proportion of it; coke is almost pure carbon; paper contains carbon, so does ink; plants, trees, etc., are composed largely of carbon, and even the human being has a large percentage of this element in his make-up.

It is now important to know what an element is. Any gas, liquid or solid which cannot be changed by some process or other which causes chemical change, into two or more substances of distinctly separate natures is called an element. On the other hand, a gas, liquid or solid which can be changed is called a compound. To illustrate, pure iron is an element because there is no way to convert it or "break it up" into anything but iron. Iron-rust, however, is a compound, because it is a chemical combination of iron and oxygen and can be divided by a chemical process into iron and oxygen. Water is a compound because it can be divided by intense heat or by electricity into two gases, hydrogen and oxygen.

These two gases, hydrogen and oxygen, are elements because it is impossible to convert them into anything but what they are. They may, however, be reunited chemically with other elements or with compounds and form many different substances. Air is neither an element nor a compound. It is simply a mixture of elements, mainly oxygen and nitrogen, which may be separated without any chemical change taking place in the mixture.

Although there are thousands of chemical compounds, there are but 79 known elements and nearly half of these are exceedingly rare ones. In the study of combustion, we deal with but the five shown in Table I.

There are two kinds of changes possible in nature, physical changes and chemical changes. A physical change is one that affects the form of a substance but not its character, while a chemical change usually affects both form and character. Two examples of physical changes are the freezing of water to form ice and the heating of water to form steam. While each of these causes the form of the water to change (in one case to a solid; in the other to a vapor) the composition remains exactly the same. If you take a lump of coal and hammer it into a powder you have caused only a physical change, for you have only changed the form of the coal from a lump to a powder which is simply a mass of very small lumps of coal having the same characteristics as the original big lump. But if you burn a lump of coal, it gives off light and heat and the coal changes into an ash and some invisible gases. This is a chemical change because the nature of the substance is completely altered. First you had coal, composed of a large proportion of carbon and small proportions of other substances, such as hydrogen, sulphur, etc. After the change you had left a little ash. The rest of the coal was converted into gases and these passed off into the air.

From this, then, we can describe combustion as a chemical combination of one or a number of combustibles (such as those in Table I), with oxygen (the supporter of combustion), when light and heat are produced.

A fact which is very fortunate from our point of view is this: Chemical elements follow exact laws when they enter into chemical combinations with each other; a fixed weight of one element always combines with a fixed weight of another to form a given compound. Also, a definite amount of heat is always created when a given combination takes place. Thus, when hydrogen, one of the combustible elements of many fuels, burns, it always requires a fixed amount of oxygen; it always causes a certain amount of heat, and it always results in a certain quantity of the product of its combustion.

Because of these facts, Table 1 becomes a very useful thing and in due time you will realize this.

TABLE 1. COMBUSTION DATA

Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6	Col. 7	Col. 8
Name of Element	Symbol of Element	Combining Weight	Combustion Formula	Compound Formed	Heat Liberated B.t.u. per lb. of Combustible	Pounds of Oxygen Required per lb. of Combustible	Pounds of Air Required per lb. of Combustible
Carbon	C	12	$C+O=CO$	Carbon Monoxide (Incomplete Combustion)	4,450	$1\frac{1}{3}$	5.76
			$C+2O=CO_2$	Carbon Dioxide (Complete Combustion)	14,600	$2\frac{2}{3}$	11.52
			$CO+O=CO_2$	Carbon Dioxide	10,150	$\frac{4}{7}$	2.47
Hydrogen	H	1	$2H+O=H_2O$	Water	62,000	8	34.56
Sulphur	S	32	$S+2O=SO_2$	Sulphur Dioxide			
			$S+3O=SO_3$	Sulphur Trioxide			
Oxygen	O	16	.....	.....			
Nitrogen	N	14	.....	.....			

Carbon

In the meantime, a few things may be said about the elements in Column 1. Carbon being the most important element in most fuels, is placed first on the list and comes first for consideration. In its pure state it is a solid, such as graphite and diamonds. As found in solid fuels, part of it is pure and part is in combination with hydrogen forming hydrogen-carbon combinations which, for brevity, are spelled and pronounced hydrocarbons. The pure carbon part of a fuel is usually referred to as "fixed carbon" because when the fuel is heated the hydrocarbons vaporize and pass off in the air, the same as water in a sponge vaporizes and passes off. The pure carbon remains behind, consequently we say it is "fixed."

In liquid fuel, such as crude oil or any of the products of crude oil, such as kerosene and gasoline, carbon is not found in the pure state but is always present in combinations with hydrogen as hydrocarbons. Carbon exists in gaseous fuels, such as natural gas, illuminating gas, blast-furnace gas, etc., but only in combination with either hydrogen or oyxgen (principally with hydrogen in the shape of hydrocarbons).

When carbon burns completely, it always requires a certain amount of oxygen, and hence, a certain amount of air, because the oxygen is supplied by the air and the proportion of oxygen found in the air is the same in New York as it is in Punxsutawney or San Francisco; in fact, the proportion remains the same the world over. You may supply more oxygen by supplying more air but the excess will not be used. A given amount of carbon will use (or combine with) only so much oxygen, never any more and never any less.

Did you notice in the beginning of the last paragraph that it was said "when carbon burns completely"? Care was taken to specify complete combustion because carbon will undergo partial or incomplete combustion when conditions are not right for complete combustion. But, this need not worry us, because this incomplete combustion also follows definite laws. A certain amount of carbon incompletely burned will use a certain amount of air every time and will give up a certain amount of heat every time. What the oxygen or air requirement is in each case and what the amount of heat is created will be taken up later. Just now we will talk about some of the other elements.

Hydrogen

Pure hydrogen is a colorless and odorless gas. It exists in coal in combination with carbon, forming the hydrocarbons mentioned before. These hydrocarbons form the principal part of the volatile matter in coal. When a coal is heated to a certain temperature, certain quantities of vapors or gases are given off, depending on the nature of the coal. With bituminous or "soft" coals, large quantities are given off; with anthracite or "hard" coals only small quantities are given off. These vapors or gases are known as the volatile matter of the coal. Hydrogen is likewise found in a combined state in the liquid fuels. In gaseous fuels it exists in both the free and the combined state.

When hydrogen burns, it burns completely; there is no part or half-way process with it as is the case with carbon. Hydrogen produces intense heat and as a fuel it has great value.

Sulphur

Sulphur in its pure state is a yellow solid substance which burns very easily and forms a disagreeable smoke. It exists to some extent in practically all coals and fuel oils. It is undesirable in fuel because its heat value is very small and because it tends to form an acid which quickly corrodes the ironwork of flues and chimneys. Sulphur also increases the clinkering properties of the coal. Ordinarily the amount of sulphur found in coal and oil is small, and hence, because its heat value is low, we can easily afford to ignore it in our calculations. It is well to bear in mind, however, that the less sulphur a fuel contains the more desirable it is.

Moisture, Ash, Etc.

In addition to the elements just mentioned, all solid fuels contain water, ash and a few other impurities. The water is usually referred to as moisture. This water cannot be squeezed out like water from a sponge, but it can practically all be dried out from coal simply by heating the coal for a certain length of time. In oil fuel, which also contains moisture, most of the water will settle out when the oil is allowed to stand for a sufficient time.

The amount of moisture which a coal contains depends almost entirely upon the nature of the coal. Some coals are more sponge-like than others; that is, they have greater capacity for holding water than others. The amount of ash or unburnable solid material in coal also varies greatly with the kind of coal, and sometimes the same kind of coal will run very unevenly in this respect. As ash and moisture do not create heat, naturally, the less of these a fuel contains the better it is.

In addition to the ash and moisture, coal contains a few other impurities, principally oxygen and nitrogen. The latter need not worry us in the least because the amount of it is small and it has but slight effect on the results anyhow. The oxygen contained in coal sometimes runs rather large in quantity and hence it is important to know about it, although in our ordinary work in boiler-room economy we can afford to forget about it, and we will, later on, when we "get down to cases." But it is a good idea to get a fair understanding of the whole story so that when we read the more technical articles and reports we will have some idea of what they are all about.

Even the scientists are not certain as to exactly what form oxygen exists in coal. They are not sure whether it is there as an element, that is, as free or uncombined oxygen; or as a compound with hydrogen in the form of water so tightly mixed up in the coal that no amount of heating, short of burning, will drive it out like ordinary water; or whether it is in the coal in some combination with carbon as carbon dioxide or CO_2. However, it is generally believed, and always assumed that the oxygen exists in the coal as a compound with hydrogen in the form of water. Hence, when an analysis of a coal shows that it contains both oxygen and hydrogen, only part of the hydrogen is considered as available for combustion. The other part is considered as being already combined chemically with the oxygen of the coal in the form of water, H_2O. And, as water is noncombustible, the hydrogen thus combined is useless as fuel. Hence, when you see the term "available hydrogen" in a report of a coal analysis, you will know that it means, not

all the hydrogen found in the coal, but only the part which is in excess of the amount required by the oxygen existing in the coal to form water.

Air

Air is composed of the gases, oxygen and nitrogen, and very small quantities of a few other elements and a few compounds. The oxygen and nitrogen form such a large part of the air (99 per cent. or more) that for all practical purposes they are the only constituents to be considered. As found in the air they are both pure, that is, uncombined with any other elements.

Some people have difficulty in realizing that a gas has weight. They think: "You never could weigh a gas; it is too light; it would not stay on the scale." Consequently, they get confused when they read about pounds of air or pounds of oxygen. It is really easy to weigh a gas if you have a good strong tank or cylinder and a pair of scales that are very sensitive and accurate. Suppose you wished to weigh air, for instance. Although air is not a simple gas, but a mixture of the two gases, oxygen and nitrogen, it makes no difference, the action is the same.

Close the valve on the tank, put the tank on the scale and weigh it. We know that the tank is full of air at

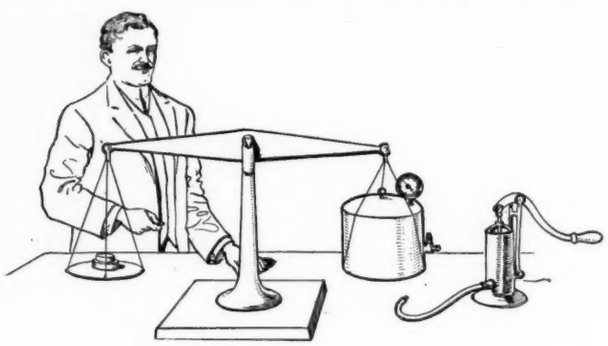


Fig. 1. Experiment To Show That Air Has Weight

atmospheric pressure, because a pressure gage attached to the tank would show zero pressure. Now, connect a good vacuum pump to the tank and pump and pump and pump until the vacuum gage shows as near 30 in. of vacuum as you can get it to show. Then, weigh the tank again. This time the weight will be less, proving that air has weight. If the temperature of the air was 60 deg., if the tank had a capacity of 5 cu.ft. and if it weighed 75 lb. the first time, it would weigh something like 74.618 lb. the second time, showing that the 5 cu.ft. of air pumped out weighed 0.382 lb. or that air at 60 deg. temperature and atmospheric pressure weighs,

$$\frac{0.382}{5} = 0.0764 \textit{ lb. per cu.ft.}$$

(By the way, it was not necessary to close the valve on the tank for the first weighing. But this is another story to be taken up later.)

You will notice that the temperature of the air when the weighing took place was specified. This was done because air (or any gas) is a very elastic fluid and expands and contracts very easily by being heated and cooled; hence its weight per cubic foot changes with change of temperature; that is, unless it happens to be inclosed in some vessel that will not let it expand. Then it is not the volume nor the weight that changes, but the pressure.

If you think of a gas as a very light fluid it is easy to realize that it has weight just the same as any other fluid, such as water.

By volume, air is composed of 21 per cent. oxygen and 79 per cent. nitrogen. That is, out of every 100 cu.ft. of air, 21 cu.ft. is oxygen and 79 nitrogen. By weight, air is composed of 23.15 per cent. oxygen and 76.85 per cent. nitrogen. That is, out of every 100 lb. of air, 23.15 lb. is oxygen and 76.85 lb. nitrogen.

OBITUARY

PHILIP H. DIEHL

Philip H. Diehl, electrical engineer, and founder of the Diehl Manufacturing Co., Elizabeth, N. J., died Apr. 7, at his home in that city at the age of sixty-six. Mr. Diehl was born in Dalsheim, Germany, Jan. 13, 1847. He came to the United States in 1868 and entered the employ of the Singer Sewing Machine Co. In 1879 he invented an arc lamp, and shortly afterward he placed on the market a small battery motor which embraced the principle of the varying air-gap for speed control. In 1884, at the Franklin Institute exhibition at Philadelphia, Mr. Diehl exhibited a dynamo which was modeled somewhat after his smaller motor and which generated energy for arc lamps, sewing-machine motors and incandescent lamps covered by his patents.

In 1887 the firm of Diehl & Co., predecessor of the present Diehl Manufacturing Co., was formed and in the late eighties the Diehl ceiling fan made its appearance. This was claimed to be the first ceiling fan possessing an individual suspended motor carrying its own separate set of blades.

One of the first of Mr. Diehl's inventions in connection with the sewing-machine industry was an individual motor of the external-ring or Siemens type which was made part of the balance wheel of the Singer sewing machine. This balance-wheel motor led to the development about 1890 of a larger motor incorporating many of the features of the smaller design, including the ring-type armature. In 1889 a bronze medal was awarded to Mr. Diehl by the American Institute of New York for electric fans and dynamos.

VICTOR DWELSHAUVERS-DERY

A distinguished scientist, particularly noted for his researches into the properties of steam and its action in the engine cylinder, and for his work for the advancement of engineering education, was Prof. Victor Dwelshauvers-Dery, who died on Mar. 5 at Liége, Belgium.

Victor Auguste Earnest Dwelshauvers-Dery was born at Dinant, Belgium, Apr. 25, 1836. Of aristocratic birth by his mother, he united a delicacy of sentiments to the love of liberty and the energy that he derived from a very democratic father. When seventeen years of age he went to study for four years at the Institute of M. Dupuich, of Brussels, where he specialized in the higher mathematics. His mind displayed a leaning toward the actual and practical, which influenced him to go to the School of Mines in the University of Liége where he took the degree of mechanical engineer in 1861. Directly, he was appointed an instructor at the university, and subsequently became a full professor, succeeding Brasseur, a famous teacher of applied mechanics, under whom he had studied.

There was then little instruction given in such subjects as resistance of materials, graphical statics, thermodynamics and the theory of the steam engine, but they were introduced by Dwelshauvers-Dery into the curriculum. He was anxious to compare theory with practice and devoted much attention to original investigation. At the London Exhibition, in 1862, he was greatly impressed by the Porter-Allen engine and forthwith purchased a novelty which Mr. Porter had shown in connection with it—a Richards high-speed indicator. This the buyer long lacked facilities at his school to use.

From 1870 on, he sought to establish an engineering laboratory for his students, but was a great while in getting it. He visited Hirn, in Alsace, and made use of an engine of that distinguished scientist for investigating the discrepancy between the pure thermodynamometric and the correct, applied theory of the steam engine. Among the

phenomena which he approached by new methods of study at Liége were those of steam condensation. About 1880 he was allowed an appropriation with which he purchased an engine for experimental laboratory work, but at first was obliged to keep it outside of the university, at his own expense. It was not until 1893 that the university granted him the mechanical laboratory he desired. To his influence may be ascribed the fact that steam laboratories were already being established by other institutions. From 1894 systematic work was conducted in his, and it was fruitful of results. The first years of research tended to show the possible usefulness of steam jacketing and of superheated steam and emphasized the importance of dry steam. One of his greatest accomplishments was the determining anew, with an engine of commercial size, the mechanical equivalent of heat.

From 1897, Dwelshauvers-Dery devoted himself entirely to work in the mechanical laboratory which had been established at the University of Liége. It was his method, when testing an engine, to have all the observations of the instruments made by a group of a dozen students, each having his duties clearly determined beforehand, readings being recorded every minute or every two minutes, etc., in a notebook prepared for the purpose. The test proper did not exceed an hour or an hour and a half, which contrasts with the hours of time generally occupied in such purposes in school laboratories. The test having ended, each observer dictated his notes to the others. The handling of

DWELSHAUVERS-DERY

these data comprised a solution of some 50 numerical problems to be worked out at home.

The method of Dwelshauvers-Dery enables the professor to realize the desire of Hirn, that the students might be made useful in new discoveries. In 1873, he proposed the question: "Is the compression of steam in the clearance space at the end of the return stroke economical?" For purely theoretical reasons, with numerous engineers, he believed in its economy; but he desired experimental confirmation. To solve this and other similar questions, he had constructed a purely experimental engine, which was flexible in its adjustments, permitting at pleasure separate changes of all the events of governing and steam distribution. For example, the degree of compression might be varied, everything else being kept the same. To the great surprise of the professor, a first long series of tests showed that compression was the more costly the more it was prolonged. He was unwilling to believe this until further tests were made with some of the conditions changed.

After having described his method of experimentation, he imparted to the public his researches upon final compression. His articles aroused the praise of some engineers. Some even tried to discredit the laboratory tests at Liége, suggesting that there had been piston leaks, shown by a hook at the end of the indicator diagram. The professor was convinced by experiment that there had been no such piston leak. When put in possession of all the original documents, Commodore Isherwood, formerly engineer-in-chief of the United States Navy, who had decided to take up the question, affirmed the absence of a piston leak. Finally, Georges Duchesne, a pupil and collaborator of Dwelshauvers-Dery, put an end to the discussion of this subject by a decisive experiment.

The professor attributed the hook at the end of the diagram to condensation produced by compression; and gave, as proof, diagrams taken upon Allis engines which showed the final hook and which certainly had not been affected by piston leaks. Duchesne, to settle the question, said: "If the hook be due to condensation it will not appear if we compress air, which is not condensable." He experimented with air and no hook appeared in the diagram.

Dwelshauvers-Dery then demonstrated experimentally that the law of expansion is not the same as that of compression.

Pursuing the investigations, Duchesne decisively showed that generally the steam is superheated at the moment when exhaust ceases and compression begins; that afterward the superheat is lost by the action of the cylinder walls and that, in certain cases, the steam rapidly condenses before the end of the stroke, this resulting in a hook.

Partly, at least, upon the basis of others' investigations, Dwelshauvers-Dery had laid down the following principle, later confirmed by experiment: "The most economical operation of the steam engine is secured when, by an efficient means, whether jacketing, superheating or other, the cylinder wall is brought to a condition of perfect dryness at the beginning of the exhaust period."

A later enunciation was as follows: "The less the quantity of water remaining on the surface of the metal of the cylinder wall at the instant of opening the exhaust passage, the less the consumption of steam by the engine. When the ratio of expansion is varied from one to another extreme of values, it will be found that the measure of steam consumption and of efficiency will pass through a series of values also, giving a minimum cost of power and maximum efficiency of steam employed at a point which corresponds to that at which this condition of final dryness of the cylinder wall is secured."

Hirn's calorimetric analysis of the steam engine was put into systematic algebraic form by Dwelshauvers-Dery.

In 1900 the professor's work was interrupted by his appointment as rector of the University of Liége and after three years he retired. Changes were introduced into the methods employed at the laboratory which, he believed, seriously compromised its usefulness, and theories were advanced which he did not approve. With health recovered after a period of being incapacitated for work, he again appeared publicly as a champion of his convictions. Two controversial letters from his pen were published in 1907 and 1908, in the Bulletin de L'Asson. des Elèves des Ecoles Spéciales de Liége; finally, in 1909, appeared his article on "The Conception of Work." In 1908, he also published in the Revue Générale des Sciences, an article on the "Conception of Mass."

In 1905, in connection with the Mechanical Congress of Liége, he was delegated to prepare a mémoire on the mechanical antiquities of Belgium and especially upon the famous hydraulic machine of Marly, erected under orders of Louis XIV, by Renkin, of Liége. The same year he edited a historical report on the mechanical progress of Belgium from 1830 to 1905.

In 1888 he was awarded by the British Institution of Civil Engineers, the Telford prize for his discussion of the steam-engine governor. In 1889, he shared with Donkin a prize for successfully investigating the thermal action of the interior of the cylinder wall. Among the societies with which he was connected was the American Society of Mechanical Engineers, which made him an honorary member in 1886.

The late Dr. R. H. Thurston, who knew Dwelshauvers-Dery well, held both the accomplishments and the character of the man in high admiration.

PERSONALS

W. G. Freer, chief engineer of the Citizens Central Bank Building, New York City, will, on May 1, become power engineer of the American Locomotive Works, at Schenectady, N. Y.

Nicholas F. Brady was elected president of the New York Edison Co., on Apr. 8. Mr. Brady succeeds his father, Anthony N. Brady, who becomes chairman of the board of directors. He is one of the youngest men in the country to be president of a large corporation. Mr. Brady worked his way up in the company's employ, after his graduation from Yale. He has been particularly interested in welfare work, and was instrumental in establishing a commercial school, an employees' savings and loan association, and a well fitted clubhouse for the men.

SOCIETY NOTES

The Detroit Engineering Society will hold its nineteenth annual meeting and banquet in the Hotel Cadillac, Friday evening, April 18. The meeting will be called to order in the hotel parlor on the first floor of the hotel promptly at 6:30 p.m. for the purpose of electing officers for the year, and transaction of other business. The banquet will be held at 8:30 p.m., and the entertainment committee is planning to make this a splendid occasion. Good speaking and music are provided.

BOOKS RECEIVED

A PRIMER OF THE INTERNAL COMBUSTION ENGINE. By H. E. Wimperis. D. Van Nostrand Co., New York. Cloth; 143 pages, 4½x6¾ in.; 60 illustrations; tables. Price, $1.

SCIENTIFIC MANAGEMENT AND EFFICIENCY IN COLLEGE ADMINISTRATION. By the Society for the Promotion of Engineering Education. Cloth; 226 pages; 5¾x8¾ in.; Price, $1.

STEAM TURBINES. By H. Wilda. D. Van Nostrand Co., New York. Cloth; 191 pages, 4½x7¼ in.; 104 illustrations; tables. Price, $1.25.

New Plant to be Erected at East Chicago, Ind.

The Northern Indiana Gas & Electric Co. will spend $750,000 this year on a new generating plant to be erected at East Chicago, Ind. Work has been going on since December.

The new plant is to be situated at the junction of the Calumet River and the Chicago Drainage Canal. It is designed for a capacity of 40,000 hp., but it is planned that two units of 6250 hp. each will be working by May 1. Transmission lines will be erected to distribute the power from the new station.

A new fuel, called "motor spirit," has been announced by the Standard Oil Co. This fuel is an additional product of petroleum, and doubles the amount of available gas-engine fuel to be obtained from a given amount of crude oil. This is accomplished by a new process, which has been patented by W. M. Burton. It is stated that the new fuel will be sold for 3c. a gallon less than gasoline, and that it will give 25 per cent. more mileage to the gallon than gasoline. It has a greater range of boiling points than gasoline, and therefore allows the motor to be started rather more easily than with gasoline. It is about 5 deg. heavier than gasoline, has a yellow color, and a somewhat strong odor, which could be done away with by a process of deodorization and distillation, but this additional refinement would increase its price. The new fuel has disadvantages in that it causes considerable smoke, and a slight carbonization of the cylinders, similar to that found when an excess of lubricating oil is used. Less lubricating oil is said to be necessary with this fuel, and that it is desirable to clean out the cylinders with kerosene about once a week.

Naval officials estimate that at the end of the present fiscal year 20,000,000 gal. of fuel oil will have been consumed by naval vessels, or 6,000,000 gal. more than was used last year and more than three times the amount used in 1911. These figures are considered important as indicating that the amount to be consumed during the fiscal year 1914 will reach a total of 30,000,000 gal., or an increase of 500 per cent. in three years. Already six battleships and 20 destroyers are burning oil, and this number will be increased by two battleships and eight destroyers next year. In addition to the many advantages which naval experts report on oil as a fuel, it is observed that the United States is the only great nation in the world with an almost inexhaustible supply.

The new 50,000-ton Cunard liner "Aquitania" will be launched at Clydebank, on Apr. 21, next. The new Gladstone Dock on the Mersey, to be opened in July, can accommodate the vessel.

NEW EQUIPMENT

ATLANTIC COAST STATES

The citizens of Chelmsford, Mass., are considering plans for the construction of a municipal electric-light plant.

The Amherst Power Co. has prepared plans for the construction of a power substation at Chicopee, Mass.

The American Printing Co., of Fall River, Mass., is to install a 1000-hp. turbine engine to increase its present power generation one-third.

The construction of a municipal electric-light plant at Paxton, Mass., is under consideration.

The Trenton Gas & Electric Co. will construct an addition to its power plant on New York Ave., Trenton, N. J. Estimated cost, $9000.

The citizens of New Castle, Penn., will hold an election June 3, to vote on the proposition to issue $200,000 in bonds for the construction of a municipal electric-light plant.

Plans are being considered by the Philadelphia Rapid Transit Co. for the construction of an addition to its power plant at Beach and Popular Sts., Philadelphia, Penn. Estimated cost, $250,000. W. L. Maize, Eighth and Dauphin Sts., Philadelphia, is purchasing agent.

SOUTHERN STATES

The Brook Electric Co., of Warwood, W. Va., is considering the construction of an electric-light plant at McMechen, W. Va.

An election will be held May 6 to vote on the proposition to issue $50,000 in bonds for the construction of a municipal electric-light plant and water system at Spencer, N. C.

The citizens of Whigham, Ga., are considering the proposition to issue $6000 in bonds for the construction of an electric-light plant.

The Hawthorne Mfg. Co., Hawthorne, Fla., is considering the installation of an electric-light plant in connection with its establishment.

CENTRAL STATES

Plans are being prepared by the United Service Co., for the construction of a new power plant at Coshocton, Ohio. Estimated cost, $150,000. C. H. Howell is superintendent.

The citizens of Centerville, Ind., recently voted to issue bonds for the construction of a municipal electric-light plnt. W. A. Butsch s twn clerk.

Plans are being considered for the construction of an electric-light plant at Waumandee, Wis.

WEST OF THE MISSISSIPPI

Preliminary arrangements are being made for the installation of an electric system at Weldon, Iowa. Bonds were recently voted for the purpose.

Plans are under consideration for the construction of a new electric-light plant at East Grand Forks, Minn.

The citizens of Fertile, Minn., are considering the proposition to construct a municipal electric-light plant.

Plans are being prepared for the construction of a municipal electric-light plant at Grand Meadow, Minn.

Plans are being prepared for the installation of an electric-light system in Hildreth, Neb. Bonds were recently voted for the purpose. C. E. Sturtevant, Holdredge, Neb., is consulting engineer.

A committee has been appointed by the council to investigate the feasibility of installing an electric-light plant at Lansford, N. D. C. A. Adams is chairman of the committee.

The citizens of Lisbon, N. D., are considering plans for an expenditure of $40,000, for the construction of a municipal electric-light plant.

Bids will be received by the city of Reynolds, N. D., until Apr. 30, for the construction of a municipal electric-light plant. Plans and specifications are on file at the office. M. N. Brathorde, city auditor. Estimated cost, $5000.

The New Salem Electric Light Co. has been granted a franchise to construct and operate an electric-light plant at New Salem, N. D.

The voters of St. Thomas, N. D., will vote, Apr. 28, on the proposition to issue bonds for the construction of an electric-light plant.

The council has granted a franchise to P. A. Prisnal to construct and operate an electric-light plant at Alice, Tex.

Press reports state that plans are being prepared for the construction of a municipal electric-light plant at Ephrata, Wash. Estimated cost, $10,000.

Plans have been prepared by J. H. Cunningham, engineer, for the construction of a municipal electric-light plant on the Clackamas River, near Portland, Ore. Estimated cost, $2,500,000.

An expenditure of $15,000 is planned by the Pacific Gas & Electric Co. for the construction of an addition to its power plant at First and Jefferson Sts., Oakland, Calif. J. H. Hunt, San Francisco, Calif., is purchasing agent.

CANADA

Plans are being prepared for the construction of a municipal electric-light plant at Berwick, N. S. Estimated cost, $15,000.

Bids will be received by M. Peterson, secretary of the board of control, Winnipeg, Man., until May 15, for furnishing two three-phase generators, 500-kw., 60-cycle, 6000-volt, for the new power plant at Point du Bois.